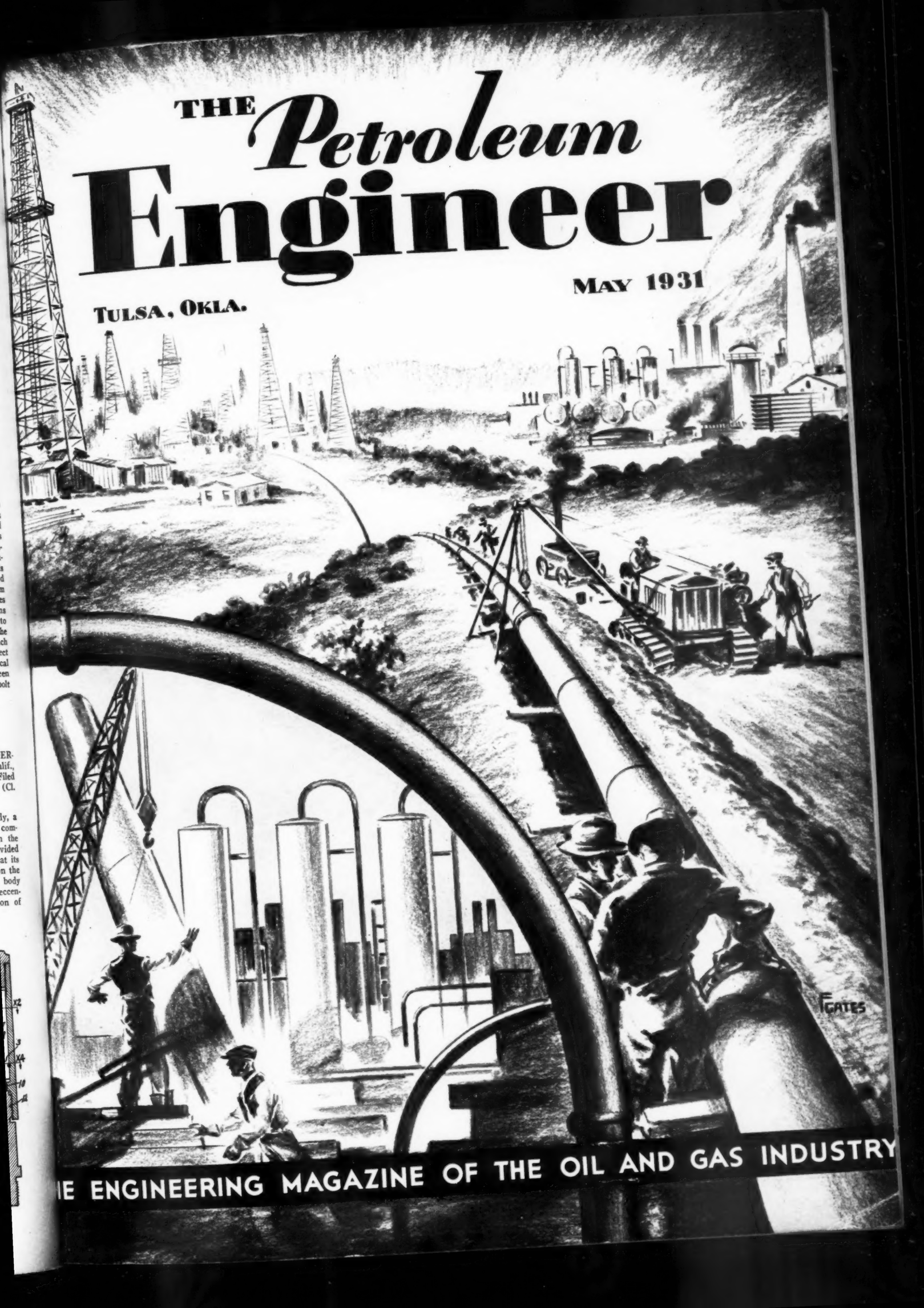
THE Petroleum Engineer

MAY 1931

TULSA, OKLA.



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Petroleum Engineer

The Engineering Magazine of the Oil and Gas Industry

Edited and Circulated Only for those Actively Engaged in the Operating Departments of the Industry

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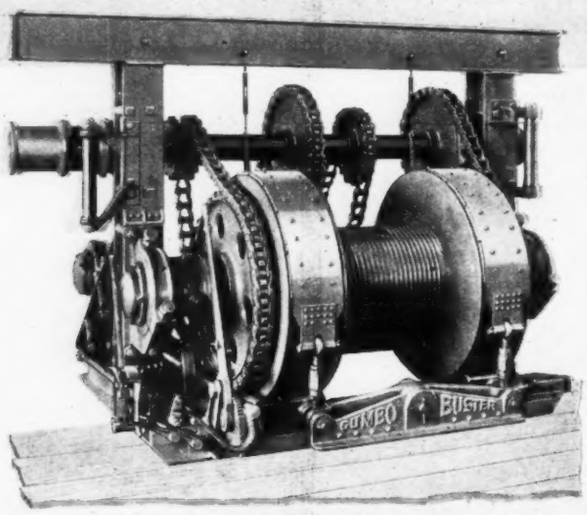

Front and rear views of the Gumbo Buster Heavy Duty Draw Works. Weight 24,150 lbs.—4 speed. Built by AMERICAN WELL AND PROSPECTING COMPANY.

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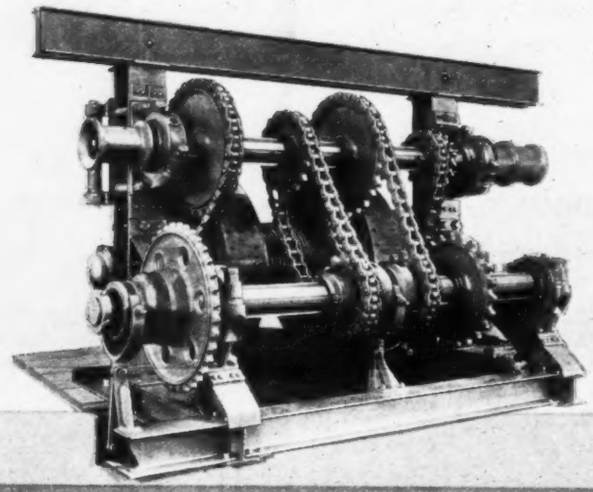
HEAVY DUTY AMERICAN



THE MONTH'S HIGH LIGHTS IN OILDOM

By J. L. DWYER

THE East Texas fields continue to hold the interest of the oil fraternity, and probably will do so for some time. From an inspection of the activity as it now appears, it is probable that the area will have on an average of ten well completions daily for the next five or possibly six months. The territory now has approximately 260 completed wells, with an output slightly exceeding 300,000 barrels daily (before proration), and there are about 350 drilling operations in the region.

Although there has been a noticeable increase of water, especially in the Kilgore area of East Texas, there still seems to be about 85,000 or possibly 90,000 acres of land which will become productive, and with an average recovery of 8,000 barrels to the acre, this means a three-quarter-billion barrel pool.

The water encroachment seems to be confined to no one class of wells. It makes its appearance in both old and new wells alike. It must not be considered as dangerous at this time, however, as there are only about 15 wells making any appreciable amount of water.

Three companies have now resorted to the installation of air lift plants in East Texas, and the field seems destined to hold excellent air lift possibilities.

An interesting development of the month was the statement by a vice-president of the Pennsylvania railroad that the railroads may find it necessary to construct gasoline pipe lines to serve refineries along their lines.

The Interstate Commerce Commission, last month, denied the application of the Humble Pipe Line Co., which had requested a twenty per cent reduction in its pipe line tariffs in numerous Texas fields.

A price reduction in the Pennsylvania fields was announced during the latter part of April by the Joseph Seep Purchasing Agency. The reductions ranged from ten to twenty cents a barrel.

The state of Louisiana will undoubtedly witness an increased wildcatting activity chiefly as a reflex of the East Texas pools. There seems to be an idea in the minds of many who have studied the region, that the East Texas formations and conditions are duplications of conditions found in Northern Louisiana.

The California fields are exceptionally quiet. Playa Del Rey field, which has been the scene of much activity, is slowing up, but during the month of May several wells are expected to be drilled into the producing formation in the Kettleman Hills region.

Production and Refining Figures Furnished by the American Petroleum Institute

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending April 28, 1931
(Figures in Barrels of 42 Gallons)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Gasoline Stocks	Gas and Fuel Oil Stocks
East Coast	100.0	483,200	78.9	8,907,000	7,730,000
Appalachian	93.8	88,600	66.9	1,824,000	1,227,000
Ind., Ill., Ky.	97.5	328,200	86.1	6,125,000	3,505,000
Okla., Kans., Mo.	89.4	277,100	67.2	3,667,000	3,938,000
Texas	91.9	360,400	75.4	7,953,000	9,002,000
Louisiana - Arkansas	98.3	167,300	63.9	2,272,000	2,327,000
Rocky Mountain	93.1	51,000	36.5	1,874,000	812,000
California	98.8	477,100	53.8	*13,829,000	98,860,000
Total Wk. April 28	95.7	2,432,900	68.1	46,451,000	127,401,000
Total Wk. April 21	95.7	2,434,100	68.2	46,384,000	126,835,000
	95.6	2,699,600	76.7	**53,713,000	**136,389,000
The Texas and Louisiana Gulf Coastal figures shown below are included above in the totals of their respective districts.					
Texas Gulf Coast	100.0	419,300	79.2	6,820,000	6,546,000
La. Gulf Coast	100.0	111,900	75.9	2,108,000	1,309,000

* Revised due to change in California gasoline stocks.
** Revised due to change in California and Louisiana-Arkansas gas and fuel oil stocks. (California, +281,000; Louisiana-Arkansas, +803,000.)

Daily Average Production
(Figures in Barrels)

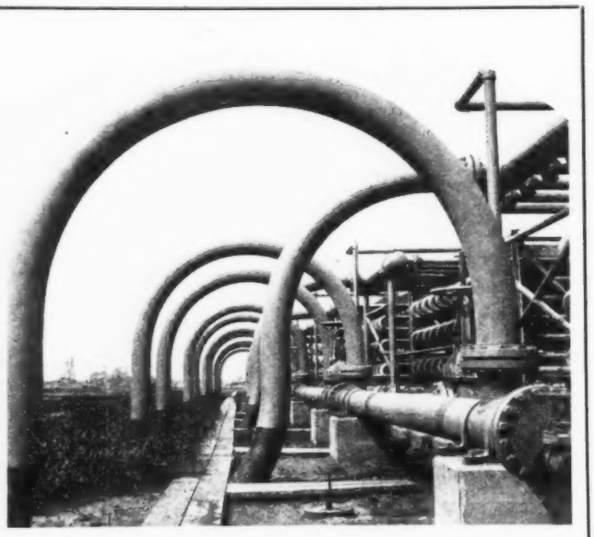
	May 2 1931	April 28 1931	April 26 1930
Oklahoma	545,300	522,800	662,050
Kansas	109,750	109,300	125,900
Panhandle Texas	55,600	55,550	95,300
North Texas	57,250	57,800	79,800
West Central Texas	25,150	25,350	61,550
West Texas	208,600	243,500	318,800
East Central Texas	49,700	169,000	36,400
East Texas	298,400		
Southwest Texas	63,200	62,750	60,550
North Louisiana	39,150	39,700	42,000
Arkansas	46,800	46,700	57,900
Coastal Texas	162,900	151,250	183,050
Coastal Louisiana	27,850	26,100	20,850
Eastern (not including Mich.)	101,750	101,700	129,000
Michigan	8,550	8,550	11,900
Wyoming	43,300	40,800	50,550
Montana	8,650	8,900	8,700
Colorado	4,050	4,200	4,400
New Mexico	38,550	41,000	10,600
California	528,100	530,400	630,800
Total	2,422,600	2,273,350	2,590,100

Cities Service Blackwell Station Produc

By J. H. AMERO

BLACKWELL, OKLA., station, with five 1,000-horsepower units, is the larger of two stations forming part of an expansion program necessitating 25,000 additional horsepower for Cities Service Gas Co. transmission lines. It is situated on the 20-inch line running north from the Oklahoma City field and forms a junction point of this line and an 8-inch line coming in from the Deer Creek field.

The site has many natural advantages, among them being an abundant water supply. Dust troubles are limited on account of the nature of the soil. Surface conditions eliminated elaborate foundation design as a safeguard against vibration of the units. In addition to the main compressor building, station buildings include a large auxiliary plant, combination office and community hall, combination garage and store room, regulator house and a five-room cottage for Frank Caldwell, plant superintendent. The site is being landscaped and chat walks built to the tanks, gate valves and other station equipment.

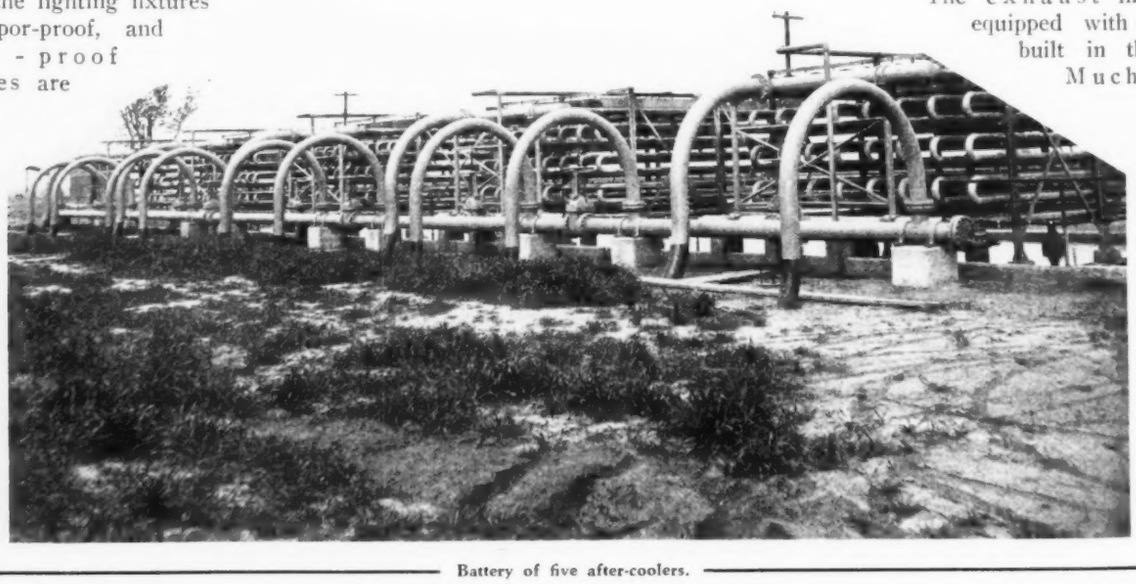


Eight-inch receiving bends and 10-inch discharge bends on after-coolers.

Brick, concrete and structural steel were used in constructing the main building. In the interior none of the station equipment extends above the water table for the windows. This not only adds to the attractiveness of the interior but makes for better visibility and ventilation. The two craneways are supported on the main columns carrying the roof load. All of the lighting fixtures are vapor-proof, and vapor-proof switches are located in one end of the building. Each of the five 21½ by 36 twin-tandem double-acting engines develop 1,000 horsepower at 125 r.p.m. They are directly connected to 13½ by 36-inch compressors. The engines are fueled from a 16-inch header running from the regulator house to the station building. Lubrication is accomplished by a double-acting pump for the bearings, and force-feed lubricators for the cylinders.

Oil from each engine drains into individual settling tanks where foreign matter settles out. One end of the pump, attached to the engine, takes the oil from the settling tank and discharges it to the filter. The other end of the pump lifts the clean oil and delivers it to the bearings. Oil and water from the bottom of the settling tank flow by gravity to a sump in the station basement. The bottom of this sump is perforated, permitting the small amount of water to seep into the ground. The oil is skimmed off and used in the gas scrubbers.

All of the engine piping is in the basement below the engine side of the station, making all piping accessible for changes or repairs without damaging the station floor. Entrance to the basement is through three hatches. Vapor-proof switches for the basement lights are located at the head of the hatches. Both the air intake and exhaust lines are located on the same side of the building, the former being protected by air filters and are located a few feet above the ground. The exhaust lines are equipped with baffles built in the top. Much of the



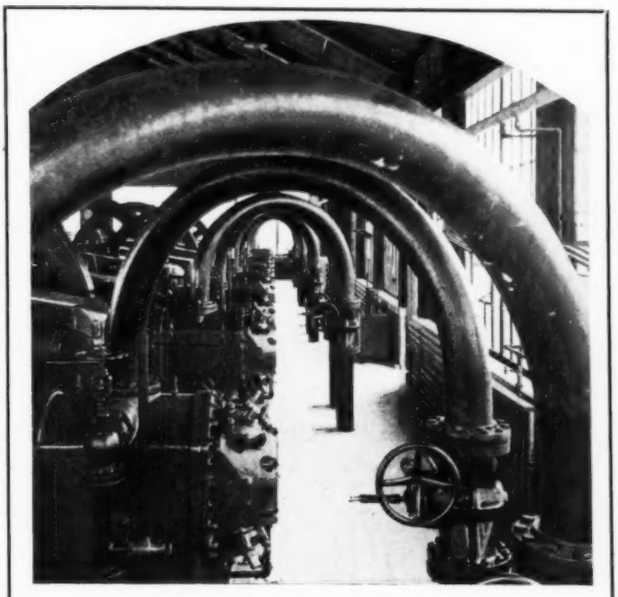
Battery of five after-coolers.

Product of Latest Construction Methods

By J. H. CAMERON

moisture in the exhaust condenses when coming in contact with the baffles and is drawn off through a small pipe to prevent its blowing over the station building and grounds.

Suction lines for each compressor extend directly up through the floor to long radius bends sweeping over the compressor to the intake valve. The 8-inch discharge lines angle through the floor to the discharge header. Both the suction and discharge lines have plug valves located inside the station. Flanges on the radius bends are attached with Vanstone joints.



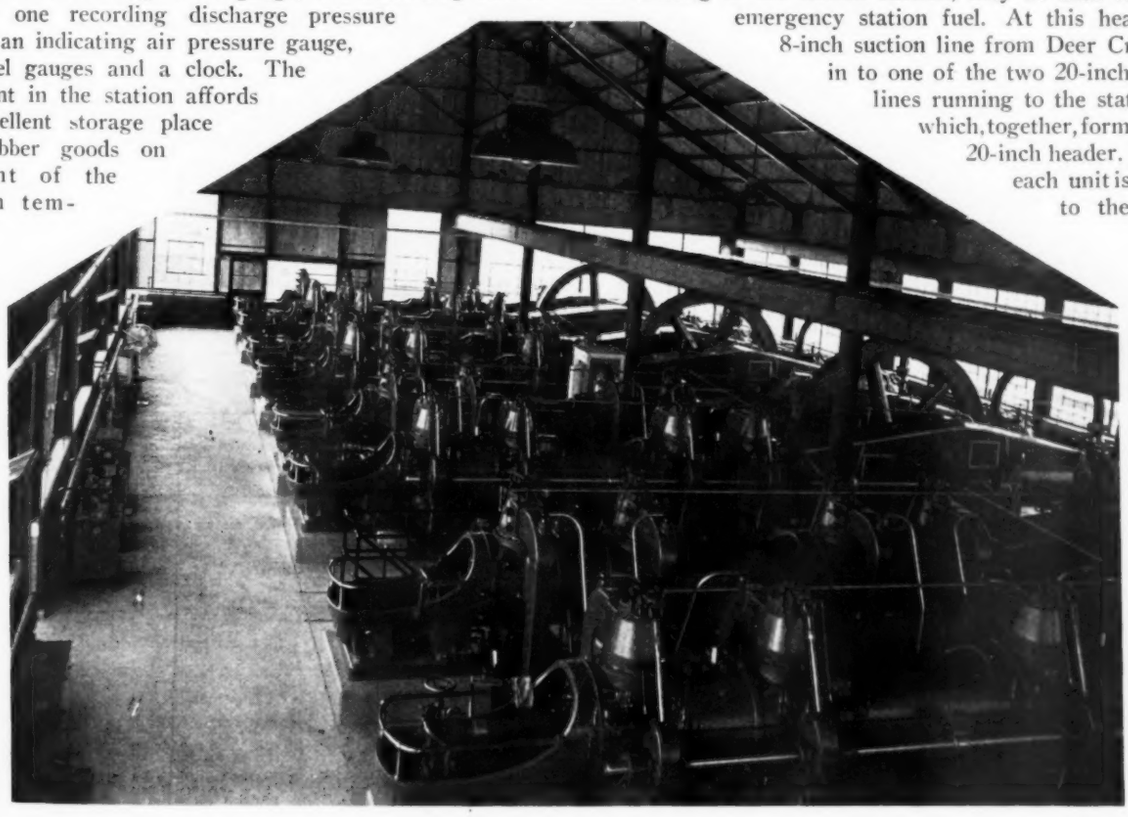
Looking down compressor end of station.

The instrument board in the station is designed to require less area, conceal piping and add to the attractiveness of the interior. In shape it is similar to a mantel clock, being a horizontal board with a 180-degree curve at the center. The ends have hinged wings with glass door fronts. These are used for safety bulletins. Virtually all of the piping is encased in a short length of painted gutter pipe. The board contains an indicating water gauge, two recording suction gauges, one recording discharge pressure gauge, an indicating air pressure gauge, two fuel gauges and a clock. The basement in the station affords an excellent storage place for rubber goods on account of the uniform temperature. Storage cabinets have been built in the walls to accommodate such material as gaskets and packing.

Gas coming in or by the station through the 20-inch line may be passed through the scrubbers located at one end of the station site. At this point the 20-inch line is blanked off with a blind flange between the suction and discharge lines on the scrubbers. A hairpin welded by-pass with a 20-inch gear gate permits by-passing by the scrubbers.

The 20-inch line has a branch to the scrubbers and 16-inch leaders extend from the 20-inch branch to each scrubber. The same diameter pipe and layout is used on the discharge side. Such a layout requires four 16-inch valves and two 20-inch valves for the incoming and discharge lines on the scrubbers.

At the main header gates the same type of by-pass used for the scrubbers is used for by-passing the station. When by-passing, a 4-inch line, tied in ahead of the gate valve and running to the station suction, may be used to supply emergency station fuel. At this header the 8-inch suction line from Deer Creek ties in to one of the two 20-inch suction lines running to the station and which, together, form a double 20-inch header. Gas for each unit is brought to the com-



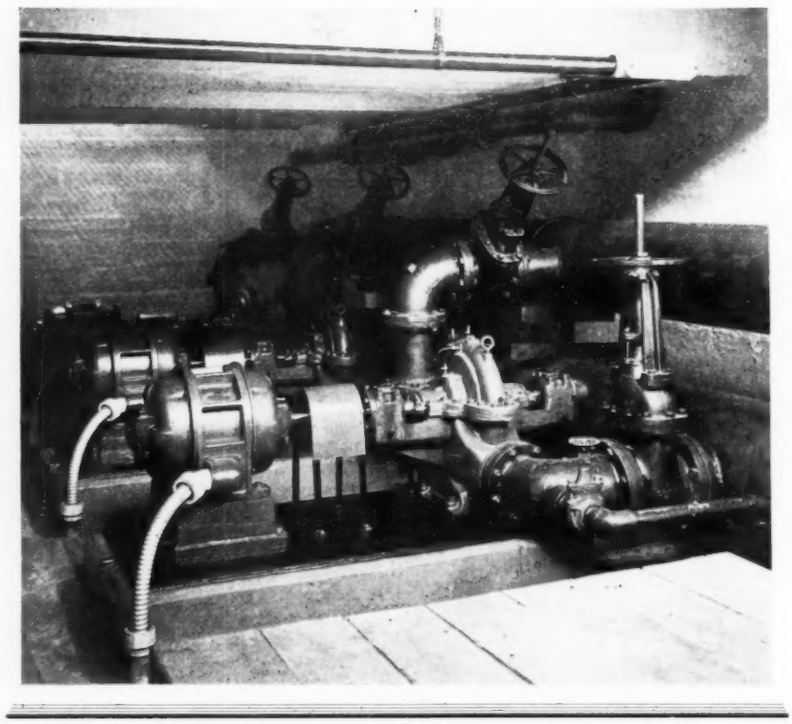
View of engine end of four 1,000-horsepower compressors.

pressors through two 8-inch lines and discharged through a pair of 8-inch lines to the after-cooler header. From the after-coolers, the gas continues to the 20-inch discharge header and back into the main line.

Gas coming into the after-cooler 10-inch header goes through discharge lines tying in to long radius bends. A 10-inch bend is used to return the gas to the 20-inch discharge header. The after-cooler header is fastened to concrete blocks extending above the ground. The return header above the main header is strapped on supports welded to the main 10-inch header and extending upright. The header gates are 1,000-pound test rising stem valves similar in type to the other yard gates.

Each unit is connected to an after-cooler made with 4-inch tubes and short radius bends. The assembly is supported on a steel frame with U-bolts, and each after-cooler contains 64 tubes. The incoming and outgoing tubes are flanged to the headers. Cooling water for the after-coolers and engines comes from the near-by river. The water is pumped with centrifugal pumps through an 18-inch line directly to the coolers. It is discharged over the coolers and the suction line for the circulating pumps is filled with the water in the cooler basin. Circulating pumps are located in the basement of the auxiliary building and discharge to the 50,000-gallon storage tank.

Cooling water to the engines flows by gravity from the elevated tank and the overflow from the tank runs into the cooler basin. Jacket water from the engine flows back to the river through a 20-inch drain line.



Circulating pumps.

The circulating pumps are motor-driven and designed to deliver 850 gallons per minute. The pumps get their suction through a 20-inch header and discharge into a 16-inch line. In designing the circulating pump pit, foundations were laid for two additional pumps in the event of future expansion. By making the design so a spacer could be inserted between flanges on the pump and the suction line, a 1,000-gallon per minute pump may be installed without having to change the piping.

Main equipment in the auxiliary building consists of two 18 by 20-inch twin, single-acting 190-horsepower (225 r.p.m.) gas engines driving three-phase, 60-cycle, 150-K. V. A., 120-kw., 440-volt generators. These supply the power for all motor-driven equipment and lighting. Each unit has an 850-r.p.m. exciter connected to it by pulleys and belts.

Indicating meters on the switchboard are equipped with glass fronts through which the figures appear indistinct unless the operator is directly in front of them. A hinged panel is attached to the board to better assist the operator in cutting in a new unit. The top instrument is a synchroscope; below it is the frequency indicator and at the bottom are the A. C. and D. C. voltmeters.

Plant equipment includes two motor-driven generators for charging the ignition batteries.

Two motor-driven (V-belt drive), 8 by 3¾ by 8 multi-stage air compressors are used for charging the starting air tanks located outside the building. One is used as a standby unit.

Pressure in the air receivers is used to flow the oil from the two 10,000-gallon lubricating oil tanks to the compressor building. A line extends from the tanks to the regulator house where the pressure is reduced to 15 pounds.

During the cold months the heavy oil is heated before it is flowed to the hand-pump containers in the compressor building. This is accomplished by inserting a small steam line inside a 4-inch heater, plugged at the end and extending the full length of the tank. The steam is jetted to the plugged end of the 4-inch heater and returns around the steam line to the front end where the condensate drains off. To assist in keeping the oil warm as it is flowed to the engine room the steam line parallels the oil line as far as practicable.

The boiler for the heating system and for the station's steam lines is designed for a working pressure of 170 pounds. It has 980 feet of heating surface and is automatically controlled. It is located in the machine shop section of the building.

All power machinery in the shop is motor-driven. Shop equipment consists of an 18-inch lathe, a 24-inch drill press, a motor-driven hack saw, a motor-driven emery wheel and a high speed drill. With this equipment station machinists are able to handle the majority of the plant's repair jobs.

The regulator house handles the fuel gas to the big engines, auxiliary engines, boiler, and gas to the cottage. The gas is measured with a recording meter.

Part of an eight-car garage is equipped as a storage room for the larger parts carried in stock at the station. Like the remainder of the station's equipment buildings it is constructed of structural steel and corrugated iron.

Floors in the main and auxiliary building are painted gray, while walkways to the equipment are black. Equipment also is painted and polished daily by a crew anxious to make a show place of the new plant.

Natural Gas Supply for Manufacture of Dry Ice

By K. C. SCLATER

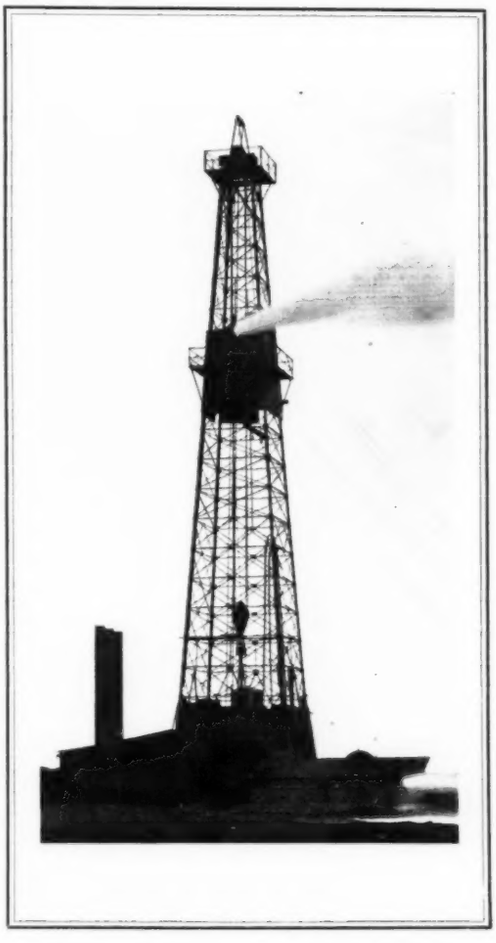
SOLID carbon dioxide manufacture has acquired added interest for those engaged in the exploitation of oil and gas lands, as a result of recent developments in this young and rapidly-growing industry.

During the last six years the manufacture of solid carbon dioxide as a commercial refrigerant has been a notable development. From 1925, when the first pound of solid carbon dioxide was sold as a commercial refrigerant, until about one year ago, all carbon dioxide gas used for the manufacture of this product either was specially prepared or was obtained as a by-product of some industrial plant. About a year ago another source of supply of carbon dioxide gas came into use. This source of supply was an oil well in Mexico, just south of Tampico.

Tons of solid carbon dioxide, manufactured from gas from this well, is now being shipped regularly into New York, where it finds a ready and profitable market. It is interesting to note that, although this well had been drilled almost fifteen years ago, and had been allowed to blow large volumes of natural carbon dioxide gas into the air continuously for about fourteen years, it is today the source of an abundant and dependable supply of carbon dioxide gas for the commercial manufacture of solid carbon dioxide.

A recently-published article,[1] to which the reader is referred, gives an excellent account of the development of this solid carbon dioxide manufacturing project in Mexico.

On the heels of this development comes the report that a commercial plant of 60 tons daily capacity for the manufacture of solid carbon dioxide from well gas will be in operation by June of this year. It will be at Walden, Colorado, and will be operated by the Dry Ice Corp. of New York. The source of supply will be a well of the Continental Oil Co. on the North McCallum Dome, in the Walden region. It was only after careful and exhaustive investigation that the construction of this plant was decided upon. Many problems were involved in the working out of a suitable commercial method for the purification of the carbon dioxide gas, and necessitated the construction and operation of a pilot plant on the location. For commercial production of solid carbon dioxide, the gas used must be absolutely free of all odor and of a high degree of purity. When oil is produced with the carbon dioxide gas from the well, as is the case at Walden, proper treatment of the gas presents many difficult problems.



Although the Continental Oil Co. has several wells producing in this area, only one will be drawn on for the supply of carbon dioxide gas. Its capacity is many times greater than the anticipated plant requirements. An interesting article on this well appeared in the January, 1930, issue of THE PETROLEUM ENGINEER.

With these developments under way a general discussion of solid carbon dioxide gas might therefore be of interest at this time.

Pure carbon dioxide gas is odorless and will not burn. It is these two properties that usually give a first inkling of the identity of carbon dioxide gas in the field. The specific gravity of carbon dioxide gas is 1.52 and its specific heat 0.193. It liquefies at a pressure of 1,100 pounds per square inch at 70 degrees F. In the presence of carbon dioxide, that is, in an atmosphere of its own gas, and at standard pressure (760 mm.), its sublimation temperature is minus 109.6 degrees F., while its latent heat of sublimation is 246 B.t.u. per pound.

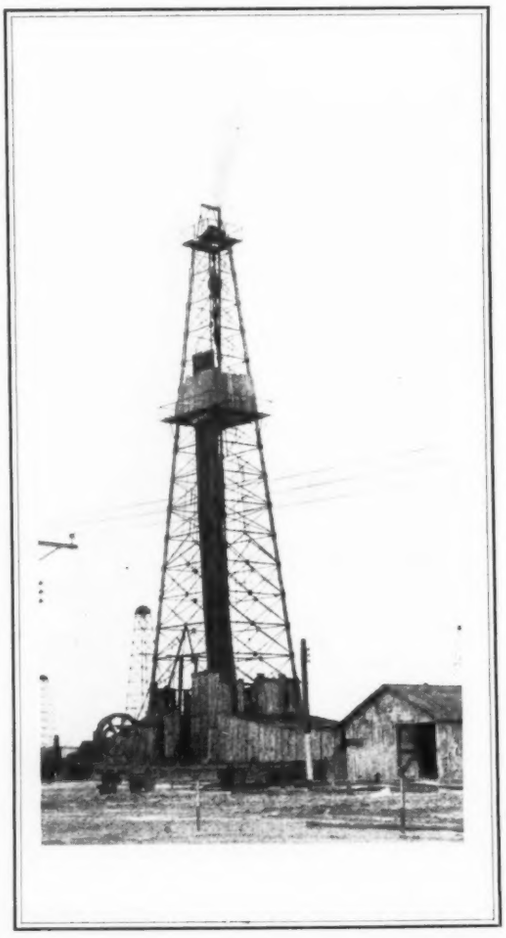
Under standard conditions of pressure and temperature 8.65 cubic feet of carbon dioxide gas weighs one pound, and in one ton (2,000 pounds) of solid carbon dioxide there is 17,300 cubic feet of gas. On account of the losses in manufacture and low temperatures required it may actually take as much as 25,000 cubic feet of gas to make one ton of solid carbon dioxide.

[1] "Solid Carbon Dioxide from Mexico," by J. W. Martin, Ind. & Eng. Chem., March, 1931.

There are three main steps in the manufacture of solid carbon dioxide from natural carbon dioxide gas; first, the purification of the gas; second, liquefaction of the gas by compression; and third, rapid evaporation of the liquid to produce carbon dioxide snow.

It is in the third named step in the commercial process of making solid carbon dioxide that vast improvements have been made. Those who have pioneered in this development have devised various methods and types of equipment to give a high snow yield. These are usually protected by patent.

Briefly, the cycle of manufacture is to take the gas and subject it to whatever chemical or scrubbing treatment is necessary to purify it. It then enters the compressors and is compressed to liquefaction. Whether or not the gas can be compressed to liquefaction in a single stage will depend largely on the well operating pressure. For high snow yield the liquid should be cooled to minus 30 or more degrees F. The liquid is then expanded through a nozzle into the snow chamber.



One type of snow chamber that has been in use is cylindrical in shape and has an inner and outer wall. It is three feet in diameter and five feet long. These snow chambers, also called solidifiers, are heavily insulated.

This step in the process consists essentially of releasing the cooled liquid, which is under high pressure, through a nozzle with a small opening into the snow chamber, which usually has a working pressure several pounds above atmospheric pressure. The already cooled liquid is converted into gas as it issues from the nozzle and the intense cooling effect produced by the rapid expansion of the gas from a high to a low pressure causes part of the gas to sublimate into a fine snowy substance which is deposited on the inside wall of the chamber. Only part (about 60 per cent under the most efficient operation) of the carbon dioxide that has passed through the nozzle is converted into snow, a small part is retained as a gas within the snow, and the remainder passes out of the chamber into the annular space between the inner and outer wall and serves to cool the snow chamber. After passing out of the snow chamber the unconverted gas may be used for final cooling of the liquid carbon dioxide before it is released to the atmosphere or returned to be recompressed and again expanded into the snow chamber. As the latent heat of the liquid carbon dioxide at 70 degrees F. is only one-fourth that of solid carbon dioxide, the snow recovery cannot be greater than about 25 per cent of the quantity of carbon dioxide expanded into the chamber if the liquid carbon dioxide is not cooled below 70 degrees F. Cooling of the liquid to a temperature of minus 30 degrees F. and lower is therefore resorted to so as to increase the snow yield.

The snow is removed from the snow chambers and compressed into blocks of convenient size and weight for shipping. A popular size in use is a block 10 inches square that weighs about 40 pounds. These are wrapped in special heavy paper for shipping.

Solid carbon dioxide is widely known as dry ice. It is a snow-like solid that absorbs about twice as much heat in evaporating as an equal quantity of ice absorbs in melting. In an atmosphere of its own gas the internal temperature of a block of solid carbon dioxide is minus 112 degrees F.

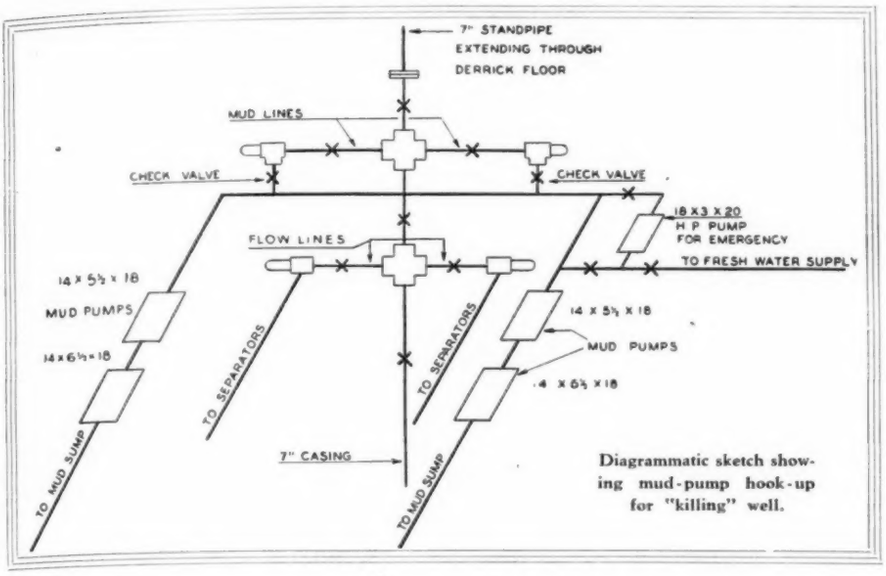
One of the most desirable properties of solid carbon dioxide is its slow rate of evaporation, which is attributed to the presence of gas-filled voids within the cake of solid carbon dioxide. It is estimated these gas-filled voids make up about 25 per cent of its volume and form an insulating layer of cold gas. Hence it is that a porous block of solid carbon dioxide has a very low heat conductivity, much lower than that of a solid block of ice.

As a refrigerant, one pound of solid carbon dioxide is almost as efficient as 14 pounds of solid ice. Also, as a rapid cooling agent, solid carbon dioxide is most effective, for, in an atmosphere of its own gas, its evaporation temperature is minus 112 degrees F., while in air its evaporation temperature is minus 137 degrees F.

Perhaps the best known and most outstanding advantage of solid carbon dioxide as a refrigerant is the absence of moisture. It is because of this property that it has been given the name dry ice. It will evaporate completely and leave nothing behind. An absence of moisture promotes cleanliness and obviates the destructive effects of corrosion and decay.

Care in the handling of solid carbon dioxide is necessary. If held too long it will result in an injury to the skin similar to that of a burn.

So many are the possibilities of solid carbon dioxide as a refrigerant that the demand for it must continue to grow at an ever-increasing rate. To what extent the oil and gas industry will participate in this development, it is still too early to predict. The progress of these pioneer commercial plants obtaining their supply of carbon dioxide from wells will certainly be followed with interest.



Diagrammatic sketch showing mud-pump hook-up for "killing" well.

"Killing" the World's Largest Deep Well

FOUR days after it blew in, somewhat unexpectedly, as the world's largest well producing from a depth below 8,000 feet, the Group No. 1 Oil Corporation's University 2-B, in the Big Lake field, Texas, was subdued.

On Thursday, April 2, the well started to flow from a depth of 8,667 feet, through 7-inch casing, at an estimated daily rate of 24,000 barrels oil and 173 million cubic feet gas. On Monday evening, April 6, after thorough preparations had been made, the well was "killed" by pumping in heavy mud fluid. The complete job of "killing" the well took only 45 minutes.

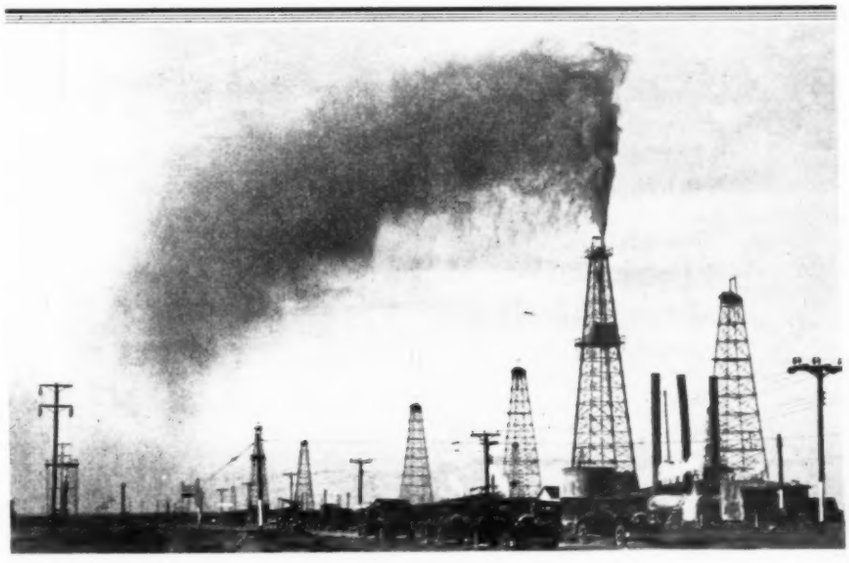
Having been taken by surprise by the prolific flow, the company found its well tankage inadequate to cope with the production of the well. It was not deemed prudent to close the well in for fear of a sudden building up of excessive pressure on the casinghead connections. Rather than place the well in jeopardy, it was allowed to produce through the flow lines until arrangements for "killing" the well could be completed, for it had been decided, on account of the acute overproduction situation existing in the oil industry, not to produce the well at this time and to close it in entirely. During the time the well was flowing before being "killed," the pressure at the casinghead was about 750 pounds and on the separators 85 pounds per square inch.

For pumping in the mud, two mud line connections were added to the Christmas tree. To these were connected two sets of mud pumps and a high-pressure pump with a fresh water supply connection. The general arrangement of the hook-up with the essential valves and fittings is shown on the accompanying sketch. A 7-inch standpipe was connected into the top of the Christmas tree and extended through the top of the derrick.

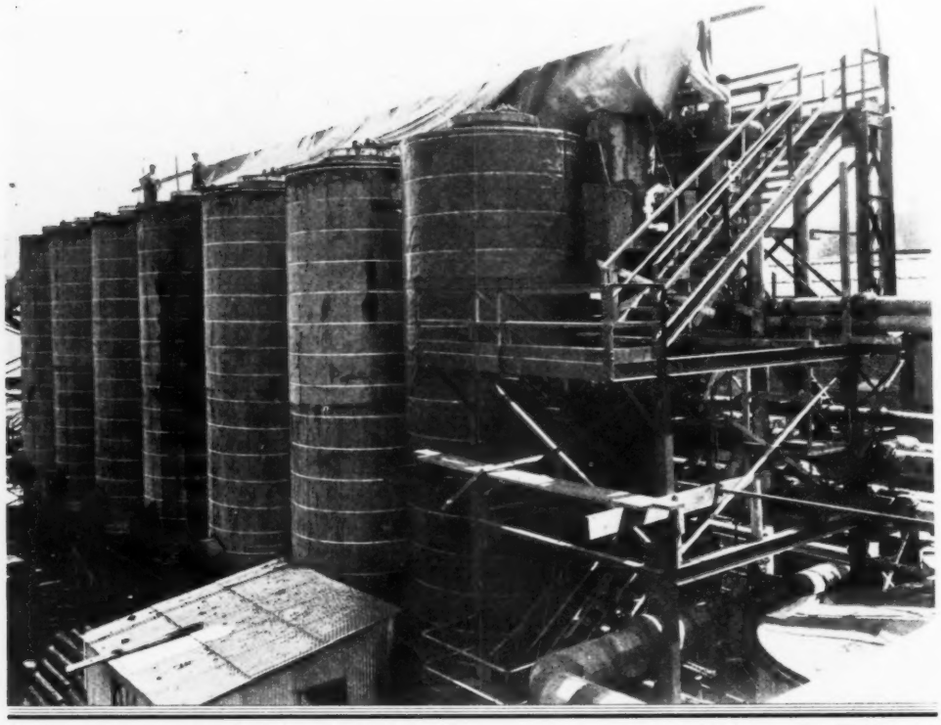
An ample supply of heavy mud (16 pounds per gallon), consisting of barite and El Paso clay, was prepared, and filled the two 100-foot by 20-foot by 10-foot sumps.

When all was in readiness the well was opened wide through the 7-inch standpipe and allow to blow for about 15 minutes. The valves in flow lines to the separators were then closed and the mud pumps started. After a few minutes, when these had had a good start, the valve in the standpipe was closed. The pressure rose suddenly to about 1600 pounds and held there for about 10 minutes, then it dropped to zero. The pumps gradually increased in speed and, about 22 minutes after closing the valve in standpipe, the casing was filled with mud and the well "killed." Three steam boilers, each 100-H. P. and 300-pound working pressure, were used.

Two mud pumps, ready for immediate service, are kept at the well as an emergency measure.



Group No. 1 Oil Corp.'s University 2-B, Big Lake field, Texas, producing through 7-inch standpipe at rate of 24,000 barrels oil and 173 million cubic feet gas daily, just before it was "killed."



Chilling towers in a dewaxing plant insulated for temperatures from —20 to —60 degrees F. Eight to 12 inches of corkboard was used.

Insulating for LOW TEMPERATURE *in* Gasoline Plants and Refineries

MANY refiners and natural gasoline manufacturers are using processes requiring temperatures considerably below atmospheric. Motor oils and bright stocks are usually dewaxed by chilling a naphtha solution of the oil to a temperature between minus 15 and minus 50 degrees F. and then centrifuging.

In a paper* recently presented by F. L. Kallam before the California Natural Gasoline Association, the author describes the method employed of cooling gas in Kettleman Hills preliminary to absorption. Propane is used as the refrigerant.

The reduced temperature permits the use of a low gas-oil ratio, resulting in an actual reduction of this figure from eight to five, the effect of which reduces both the investment and the operating cost. The author predicts considerable advancement in the use of refrigeration in the natural gasoline industry.

In recent years much study and research work have been done to develop and improve insulation material for both high and low temperature operations. In the design of a plant employing reduced temperatures the engineer should first of all be careful to select the proper material for insulation, and then make provision for its proper application. One authority states that the amount of refrigeration required depends largely upon the insulation efficiency.

Cork is most widely used as an insulating material for low temperature insulation. A satisfactory material for this purpose should possess the following characteristics:

1—Permanently nonabsorbent of moisture, for water is an excellent conductor of heat and any material that absorbs moisture becomes useless as insulation.

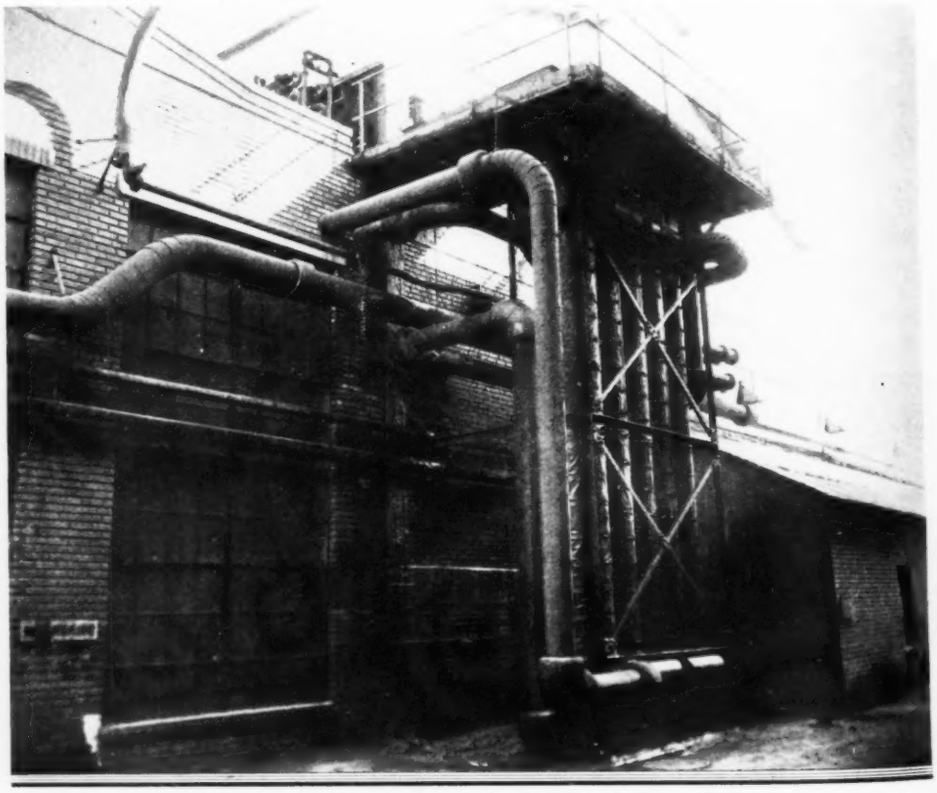
2—Structurally strong and stable so that it will stay permanently in place without sagging, settling, shrinking, swelling, or warping.

3—Free from objectionable odor and from any liability to rot or mold, or to harbor vermin.

4—Readily handled and erected by available labor and with ordinary tools.

5—Slow burning and fire retardant.

6—Reasonable in cost of material and erection.

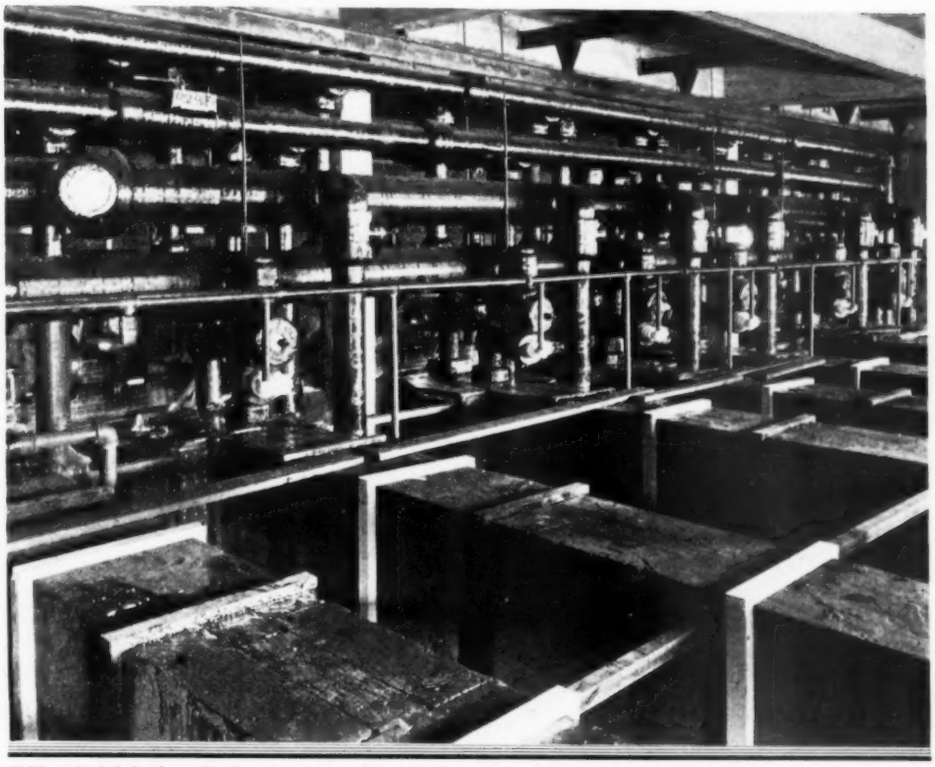


Double pipe oil chiller insulated with corkboard for —20 degrees F.

* Refrigeration in the Natural Gasoline Industry, January, 1931, Meeting.

for PERATURES Plants and

By
F. R. STALEY



Chillers in lubricating oil plant insulated with six-inch cork lagging and weatherproofed. Top and bottom connections insulated with granulated cork encased in steel shells. Brine and oil lines insulated with special cork covering.

*Calculations of Heat Losses**

The heat loss per square foot of pipe surface may be calculated by the formula:

$$H = \frac{(t_1 - t_2) \times B \times S}{(T_1 - T_2) \times A}$$

in which

$(t_1 - t_2)$ = temperature rise in brine through test section.

B = pounds brine flowing per hour.

S = specific heat of brine.

$(T_1 - T_2)$ = temperature difference between brine and covering surface.

A = area of ten-foot test section of pipe.

The thermal conductivity of the cork in the covering, including also the outer mineral-rubber finish, is calculated from H by substituting in the accepted formula for heat flow through cylindrical surfaces

$$H = \frac{C}{\frac{D_1}{2} \log_e \frac{D_2}{D_1}}$$

in which

H = heat flow per sq. ft. pipe surface

C = conductivity of material

D_1 = inner diameter of covering

D_2 = outer diameter of covering

The conversion of thermal conductivity into heat flow per lineal foot of pipe in various sizes and thicknesses of cork covering was accomplished by the formula:

Heat flow in B. t. u. per lineal foot of pipe per hour

$$= \frac{.262\ D_2\ EC}{C + E\frac{D_2}{2} \log_e \frac{D_2}{D_1}} (T_0 - T_2)$$

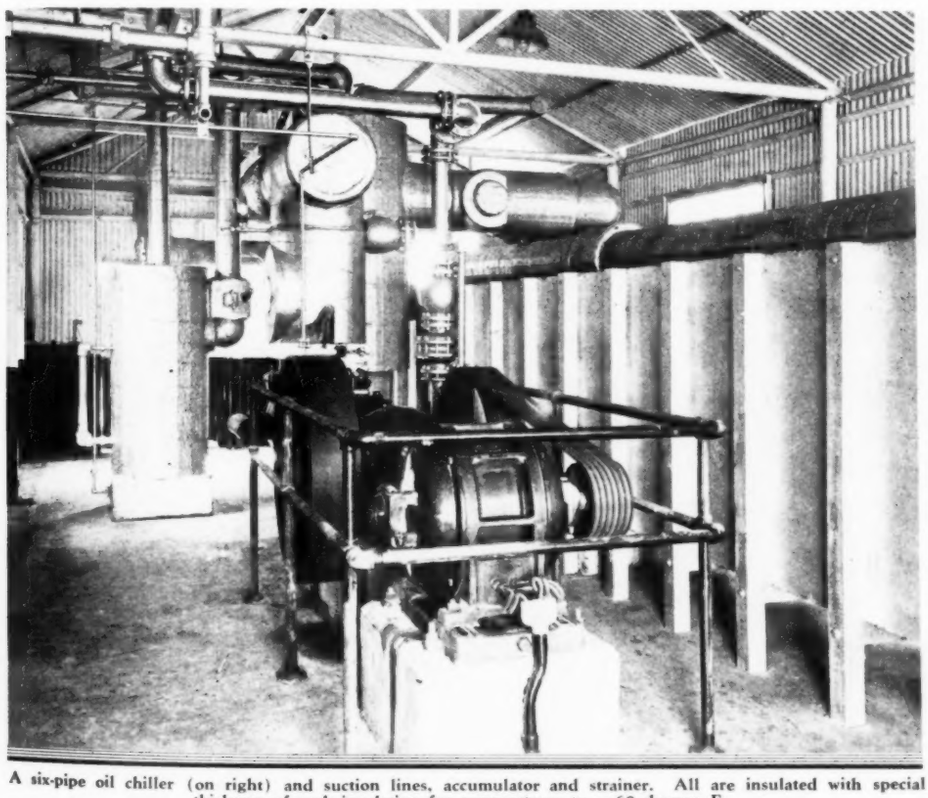
in which

D_1 = outside diameter of pipe

D_2 = outside diameter of covering

T_2 = brine temperature

T_0 = room temperature



A six-pipe oil chiller (on right) and suction lines, accumulator and strainer. All are insulated with special thickness of cork insulation for temperatures to —60 degrees F.

* Armstrong Cork & Insulation Co., Pittsburgh, Pa.

C = conductivity of cork covering
E = surface transmission co-efficient in B. t. u. per sq. ft. per degree F. per hour. (With an average room temperature of 80 degrees F. and still air, E = 1.35)

Dividing the results gained by substitution in the above formula by $(T_0 - T_1)$ gives the transmission per degree F. temperature difference.

Applications of Cork Insulation

A manufacturer of cork insulation outlines the following applications in refinery service:

Specifications for the insulation of wax press rooms should provide for continuous unbroken insulation from the floor line to the roof. Slots are provided in the platform slabs and roof slabs so that the wall insulation can be made continuous and the beams supporting these slabs are insulated at both ends. The roof insulation is applied directly to the top of the slab and built-up roofing is laid directly over the corkboard. The floors are usually not insulated because of the many concrete footings and piers supporting the presses. However, where steel columns are employed to support the presses the floor can easily be insulated and it is recommended. The operating temperatures of these rooms vary from 15 degrees to 30 degrees. The walls and roofs are usually insulated with from four to six inches of corkboard, depending upon the operating temperature. The corkboard of the walls should be finished with hard Portland cement instead of an asphaltic compound as asphaltic mixture has a tendency to dissolve and run when exposed to wax and oil. Standard cold storage doors, insulated with corkboard, should be provided at all openings.

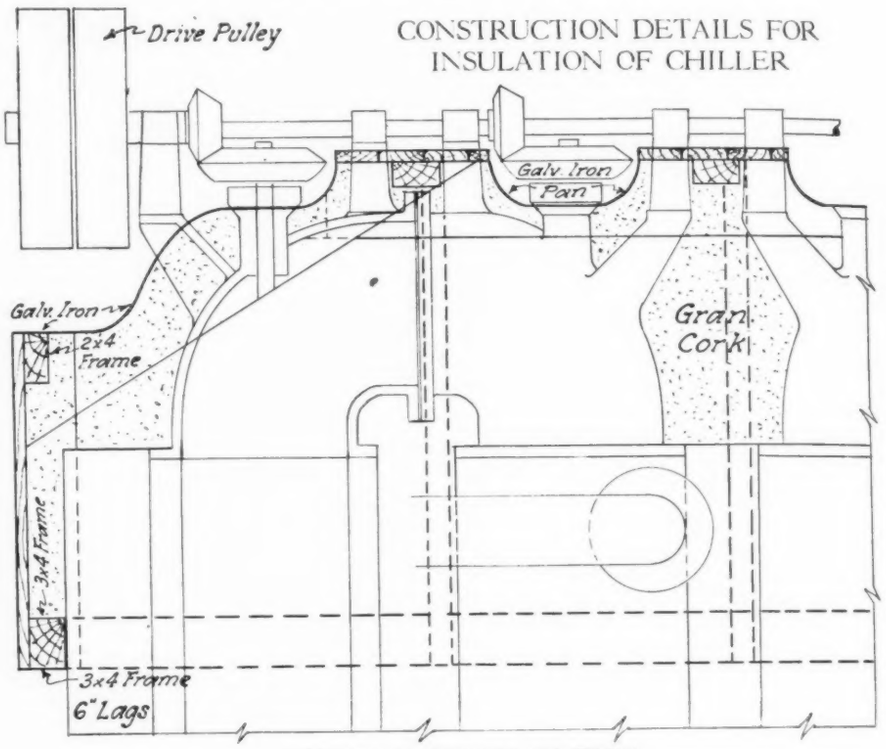
All brine circulating mains, ammonia suction lines and cold oil lines should be insulated with the proper thickness of cork pipe covering. The thickness of insulation can be obtained from the manufacturer's catalog. Where the temperatures fall below minus 25 degrees F. special thicknesses of cork covering are provided. These thicknesses are entirely dependent upon the size of pipe and operating temperature.

Brine coolers, accumulators, suction traps, small tanks, etc., should be insulated with corkboard lagging. The following thicknesses are recommended:

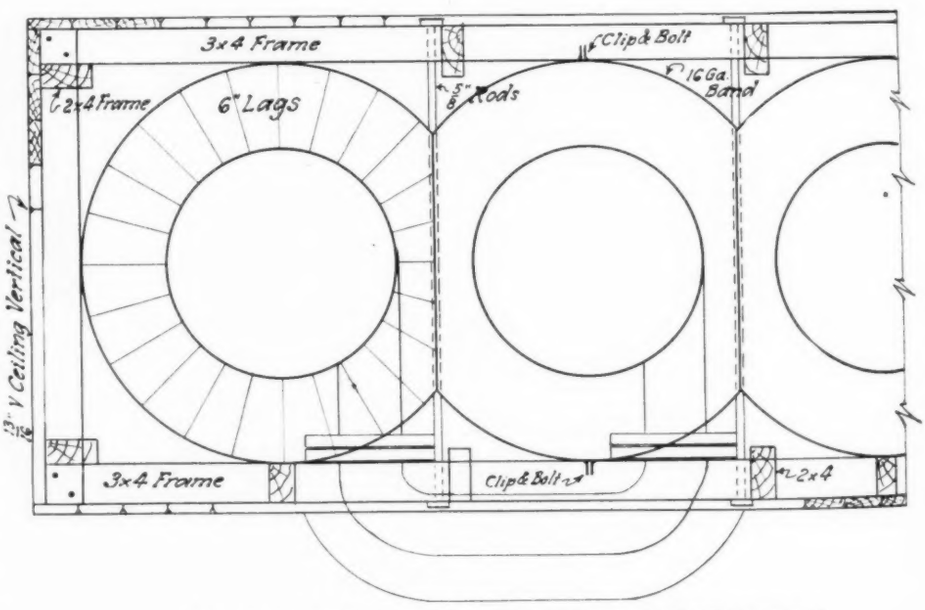
Temperatures	Thickness
Below 5° F.	6 inches
5° to 20° F.	5 inches
20° to 32° F.	4 inches
32° to 55° F.	3 inches
55° to 65° F.	2 inches
Above 65° F.	1½ inches

Vertical chilling tanks or towers range from eight to 25 feet in diameter by 25 feet to 35 feet high and are usually operated in series, the oil often entering the tank at 100 degrees F. and leaving the last tank at —40 degrees or —50 degrees F. Obviously, the insulation for each tank should be designed for the respective temperatures. The insulation is erected in multiple layers of corkboard and if necessary the corkboard is scored to facilitate bending to the diameter of the tank.

CONSTRUCTION DETAILS FOR INSULATION OF CHILLER



PARTIAL VERTICAL SECTION SHOWING TOP CONSTRUCTION



PLAN SHOWING TOP & BOTTOM CONSTRUCTION

The Physical Constants *of* Petroleum Fractions

By
W. L. NELSON,
Professor of Petroleum Engineering, University of Tulsa

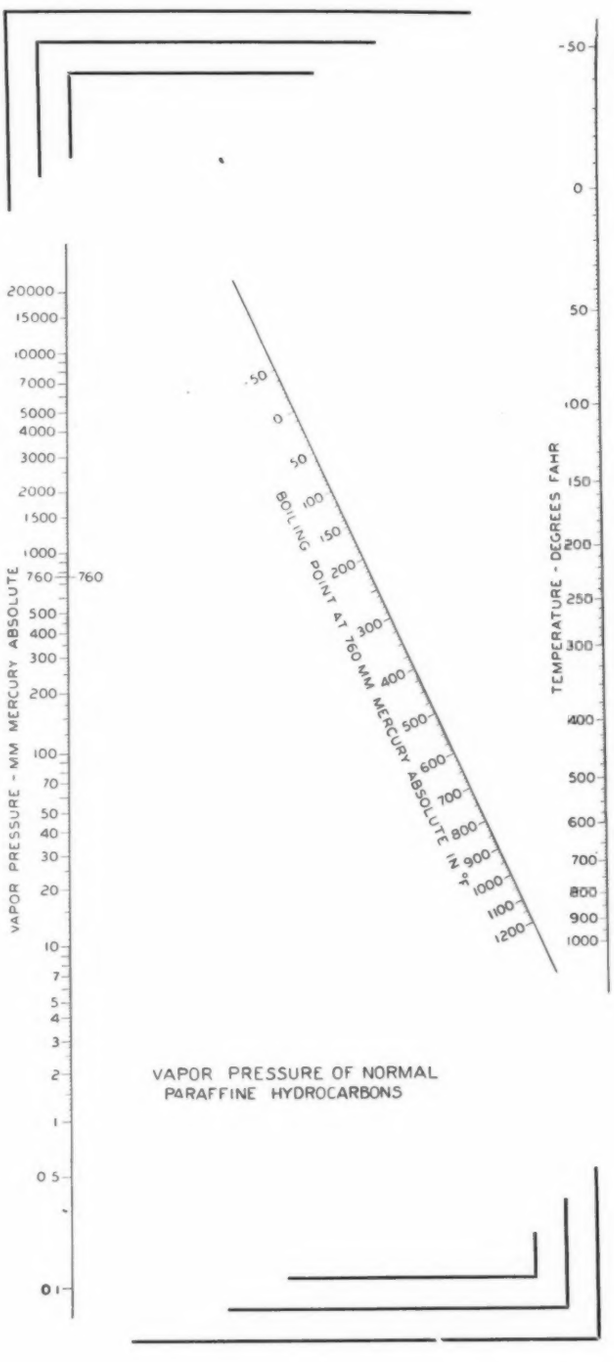
IN TWO previous articles in this publication* the evaluation of a crude oil was presented from the standpoint of the compounds composing the oil and of the typical analyses necessary for design calculations. However, evaluation cannot be said to be complete until the physical constants of the oil itself, or fractions thereof, have been adopted. Petroleum is such a truly complex raw material that the selection of the proper physical constants is difficult. Further, not only is petroleum complex, but the crude oil from various localities is widely different in characteristics. Of course this series of articles cannot settle this complicated problem, but an endeavor has been made to point out several angles of approach, so that, if not by a single indication, the sum total examination will be dependable.

For design purposes the following constants and data are necessary:

(1) Molecular Weights.
(2) Boiling Point Corrections.
(3) Specific Gravity—Temperature Relations.
(4) Specific Heats.
(5) Latent Heats.
(6) Specific Volumes.

Although there are many other important constants, they do not compare with the foregoing in general usefulness. The material presented in this article is not represented as being original. However, there are those who will welcome an introduction to these constants and others who will be gratified to find the information brought to date.

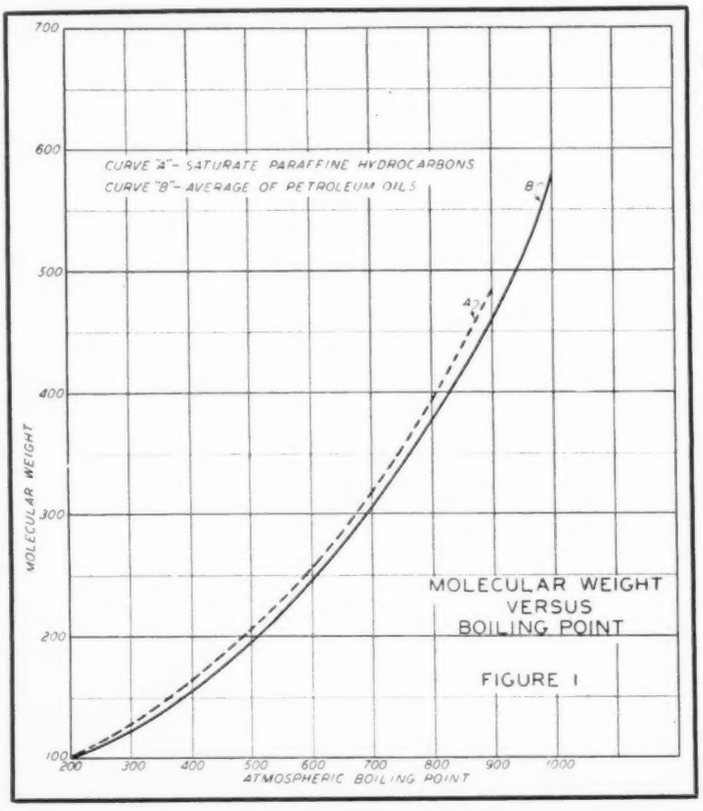
Molecular weights have always been troublesome to designers. Due to the scarcity of information and the questionable accuracy of that available, engineers have most frequently employed the molecular weights of the normal paraffins. Another difficulty in the accumulation of molecular weight data is, that it often relates to specific gravity rather than to boiling point. Correlation against specific gravity seems to be hopeless. Discrepancy, which occurs even when plotting against boiling points, probably arises because of the methods used in obtaining the molecular weights. Apparently the most successful method is the cryoscopic method. Molecular weights are determined at several concentrations so that extrapolation to zero per cent solvent concentration is possible. Up to an atmospheric boiling point of 900 degrees F., molecular weights closely approximate those of the normal paraffins. (See references [1] to [28], inclusive.) Above 900 degrees F. the data is not consistent, although in general the molecular weights are less than those of the paraffins of the same boiling point. Apparently the treatment which oils undergo in distillation and refining has a pronounced effect upon the molecular weight. Mabery, Davis & McAllister, and others, have reported molecular weights of 700 at 990 degrees F., while solvent dewaxed oils have been reported to show molecular weights of 450 at the same temperature. Other, and perhaps more dependable information (28), checks consistently with itself from 900 to 1,000 degrees F., as indicated in Fig. 1. It will be noted that the average molecular weights of petroleum cuts is approximately 5 per cent less than those of the normal paraffins of the same boiling point.



The correction of boiling points from one pressure to another has been, and still is, the subject of much controversy. The most convenient, as well as the latest information, was published by O. G. Wilson (29) in the form of a nomographic chart. Meanwhile the Natural Gaso-

*March and April issues.

line Association of America, under the supervision of Dr. G. G. Brown, has made a complete study of the vapor pressures of the lighter hydrocarbons. Their work completes the vapor pressures of heptane to pentadecane, inclusively, down to a pressure of 0.001 mm. Wilson's chart appears to be accurate down to pressures of 100 mm. when compared with these data. However, Wilson's and Brown's data cover only the normal paraffin series. Other vapor pressure data (30), (31), (32) and (35), dealing with other hydrocarbons, indicate in general that petroleum oil boiling point corrections are greater than those of the normal paraffins when converting from vacuum conditions back to atmospheric. All of the various series of hydrocarbons, with the exception of the acetylenes and aromatics, give straight lines when plotted on Brown's chart. In general the acetylenes (35) give a smaller correction (or slope upward) whereas the naphthenes, olefins (35), isoparaffins, aromatics and most other series give a larger correction than do the normal paraffins. Steinschneider (33) gives boiling point corrections for five typical petroleum oil cuts. Steinschneider's work, along with other and more scanty data (34) on petroleum oil, agrees with the above data for the pure compounds. These data all show a downward curve when plotted on Brown's chart and give larger corrections from low to higher pressures than do the normal paraffins. Such might have been expected from the vapor pressures of the series, since the acetylenes, the only series which slopes upward, are present in only small amounts in petroleum and hence the effect of acetylenes would be entirely overshadowed by the effect of the other series. Petroleum oils probably give corrections 10-50 degrees F. larger than the corrections for the paraffins when correcting from 10 mm. up to 760 mm. The higher boiling compounds deviate most widely.



A revised and extended boiling point correction chart is presented in Figure II.

The author has nothing noteworthy to contribute regarding specific gravity, specific heats, latent heats and specific volumes. The United States Bureau of Standards, Miscellaneous Publication No. 97 (1929), treats these properties quite completely. However, latent heats should be used with extreme caution. The latent heat of vaporization varies with temperature, or as the boiling point is altered by pressure (36 and 32). In pressure calculations this amounts to quite an item since many oils are nearly at the critical temperature. At critical conditions the latent heat is zero. The Bureau of Standards Publication No. 97, in its tabulations of latent heat, takes into account the temperatures at which vaporization occurs.

While none of the data presented in the three articles has been of a fundamental scientific nature, nevertheless it was presented from a new standpoint, namely, that of the engineer. Heretofore petroleum engineering has been guided by the efforts of chemists and scientists. Execution was handled by the mechanical engineers, who, in spite of their fine development of the industry, were not basically trained to handle such work. A thorough knowledge of the above fundamental background enables the engineer to estimate wisely the many details of design which have previously been neglected. The refinery design engineer has a particularly difficult problem because crude oil is such a complex material. Information obtained from such a material cannot be superficially correlated so that duplicate plants can be built to operate at maximum efficiency on another oil. The industry is demanding more and more that each construction job be a "tailor-made" one. Companies which have been successful heretofore by following "rule of thumb" methods are finding themselves unsuccessful in the new competition.

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Problems of Natural Gasoline Manufacture

By EMBY KAYE, *Skelly Oil Co.*

WHEN a professor from an Eastern university[1] recently segregated certain petroleum hydrocarbons from gasoline, it was carried as important news by the Associated Press. While it played up the possibility of improving the detonating qualities by the removal of objectionable components of gasoline, the article focused attention upon the progress made in the art of fractionation in the oil industry.

Fractionating of a sort was used in the refinery a decade and a half ago, but the modern bubble column achieved a place of importance only in recent years. It was rather in the sister industry—natural gasoline manufacture—that it received a great deal of development by "trial and error" and by the enfolding of definite engineering and empirical data. It is not quite ten years since the first "stabilizer" was built in a Mid-Continent natural gasoline plant. Today no modern plant is without one. The first plants were atmospheric towers. Today's efficient fractionators are high-pressure units.

Gasoline plant for making special products, Skelly Oil Co.

Much has been written about rectification of natural gasoline.[2] The object of such rectification was to control the vapor pressure of the raw gasoline in order to produce a merchantable product. As extraction efficiency increased, more propane, isobutane, and butane were extracted, part of which had to be eliminated from the final product. In today's plant all of the propane can be rejected and only so much of the butanes retained as is desired by the operator. This rejection of propane permits the retention of approximately four times its liquid volume of butane, with the result that an over-all increase of 3 per cent may be obtained with no change in the vapor pressure of the material.

It is precisely for this reason that every modern refinery employs rectification as one of its important processes. Whereas at first it used the bubble tower to cut out an overhead gasoline, it now takes off side streams of each of the products of primary distillation. As an incident to debutanization of pressure distillate, it was found[3] that not only would it save the cost of acid treating these lighter fractions, but the high anti-knock aromatics were not destroyed, since they were not subjected to acid treating. The undesirable sulphur compounds are eliminated when that product is processed with the vapor recovery gasoline through high-pressure rectifiers.

It is by this time common knowledge that several natural gasoline manufacturers have carried rectification further and have segregated practically pure propane for use chiefly in the bottled gas industry, which has been developed to commercial proportions in the past five years. They have likewise segregated butanes within narrow boiling ranges (18°) for use as industrial and domestic fuel, which has been gaining increasing acceptance during the three years since it was introduced by leading natural gasoline manufacturers.[4] Another product which has been made available by several manufacturers is pentane with a boiling range of 80 to 100 degrees F. At the present time the market is limited to fuel for gas machines,[5] raw material for chemical manufacturing, and as solvent substitutes in a few isolated industries. The market has thus far not justified a greater availability of this material.

At least one manufacturer[6] is producing a variegated number of petroleum solvents of almost pure chemical composition. In its plants it has developed a number of solvents to meet special uses in the industrial solvent field. Some of the specifications of these products are:

Color, 30; Doctor, Sweet; Non-corrosive.

82° to 100° F.	171° to 239° F.	140° to 249° F.
86° to 140° F.	186° to 212° F.	195° to 320° F.
104° to 167° F.	212° to 284° F.	225° to 283° F.
140° to 160-165° F.	110° to 225° F.	300° to 405° F.
140° to 205° F.	110° to 290° F.	

With its plants, one of which is shown on this page, it can segregate particular hydrocarbons as closely as it desires. Simple operating data have been developed which enable the average operator to manipulate the plant at will, according to the particular product he is trying to produce. The segregated fractions are subjected to the refinements of chemical treating in order to remove all traces of sulphur and other impurities. Each product is packed in a can, barrel, or car through separate handling facilities, in order to eliminate any possibility of contaminating the product, as obviously with materials of such different boiling ranges, every chance of contamination must be removed.

[1] Pennsylvania State College.
[2] Thompson, Oberfell, Robinson, Gregory, Campbell, Carney.
[3] Bureau of Mines Bulletin.
[4] Phillips Petroleum Co., Skelly Oil Co., Standard Oil Co. of California.
[5] Such as Delco Gas.
[6] Skelly Oil Company, manufacturer of Skellysolves.

Only TRANSIT HOT OIL PUMPS have this Construction

Improper mounting of fluid cylinders on hot oil pumps is responsible for a great deal of trouble.

Early in our experience, we had to solve the problem of mounting fluid cylinders, on hot oil pumps, so that they would "float" in their mountings.

The illustration above shows how we have solved the problem.

The cylinder is supported at the center line of the bore, permitting expansion in all directions with no change in alignment. Each fluid cylinder is mounted on two water-cooled saddles as shown. There are no supports on the bottom.

Note particularly how advantageously the saddles are placed--no possible chance for any distortion of the cylinder.

Los Angeles
Tulsa
Houston

NATIONAL TRANSIT
PUMP & MACHINE CO.
OIL CITY, PA.

New York
Philadelphia
Cleveland
Pittsburgh

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NEW ORLEANS, LA.
Woodward, Wight & Co.

SALT LAKE CITY, UTAH
F. C. Richmond Machinery Co.

LOS ANGELES
Republic Supply Company of California

BEAUMONT, TEXAS
E. L. Wilson Hardware Company

PHOENIX, ARIZ.
Pratt-Gilbert Co.

ST. LOUIS, MO.
Reeves & Skinner Machinery Co.

When writing NATIONAL TRANSIT PUMP & MACHINE CO. *please mention The Petroleum Engineer*

Gasoline Pipe Line *Nearing* Completion

BLASTING their way through rocky Osage hills and cutting through the rolling country, the Southwestern Construction Corporation, contractors, completed the south end of the Great Lakes Pipe Line Co.'s 4- and 6-inch line in rapid time, considering the weather and nature of the country traversed. This 117 miles of line connects Muskogee, Okmulgee and Tulsa refineries with the main gasoline line at Barnsdall, which continues north to the Great Lakes region.

Top to bottom—Ditching machine working over level country; coating the line; backfilling; lowering the pipe.

Construction work on this section was started late in January and completed early in April. The most difficult part of the work was ditching through the Osage hills. Here the ditching gangs encountered 30 miles of broken and rocky country. Ditching straight through with machines was impossible, so shovel gangs, working behind blasting crews, removed the shattered rock from the ditch.

The south end of the line, 10 miles, near Okmulgee, also offered difficulties. Portable air compressors were used to drive the hand-operated air drills digging the shot holes. These were spaced and loaded according to the amount of rock to be shattered. Each series of shots, exploded by separate caps, hurled part of the rock from the ditch and shattered the remainder sufficiently to permit easy deepening of the trench to get a 30-inch covering over the line.

Ditching through the rolling country to the south was done with machines and accomplished speedily.

The Arkansas river near the Mid-Continent Co.'s refinery in West Tulsa was the only major stream crossing in the entire section. This crossing was made up with two 8-inch lines with reinforcing straps on each weld and heavy clamps bolted to each joint. The crossing is 2,900 feet long from header to header. Lines were pulled across with tractors and were bowed upstream and permitted to sink of their own weight in the sandy river bed.

The 40-mile section from Muskogee to Okmulgee was built with 4-inch, 30-foot line pipe. It was acetylene welded in five-length sections and tied in by bell hole welders. Teams were used on this section to make the bends and lower the line in the ditch, while machines did the backfilling.

The 6-inch pipe was shipped in random lengths averaging 36 feet. These were rolled welded in five-joint sections. A fast burning rod was used to make the welds, ¾-inch wide and 3/32-inch high, on both the 4- and 6-inch pipe. To insure better workmanship the welds were inspected by both the contracting company and pipe line company inspectors. On an average it required 22 minutes to make a roll weld on the 6-inch and 16 minutes on the 4-inch.

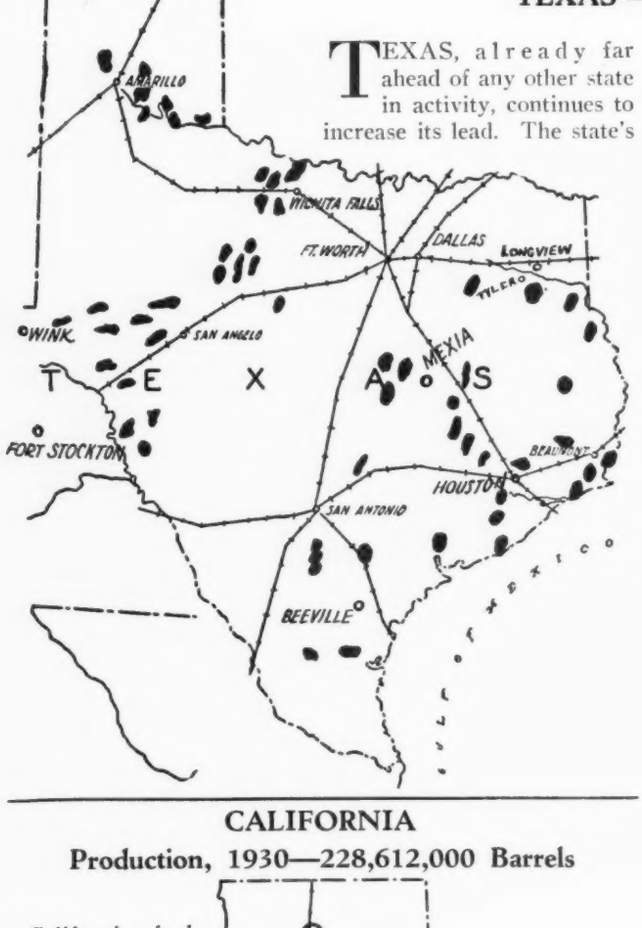
During the entire construction period only two gangs were working, one on the south end and the other on the north end.

Station construction on the south end progressed as rapidly as line construction. Upon completion of the line it was tested with water and the pressure built up with the Diesel-powered reciprocating pumps in stations located near the refineries.

With this section of its 1440 miles system completed the Great Lakes Co. is ready to pump refined products from refineries located at Muskogee, Okmulgee, Tulsa, Barnsdall and Ponca City, Okla., as far north as Kansas City, Mo. Line construction north to St. Paul, Minn., has been completed and work is progressing rapidly on the section to Chicago, Ill.

Latest Activities *in the* Oil Fields*

TEXAS—Production, 1930—290,720,000 Barrels



TEXAS, already far ahead of any other state in activity, continues to increase its lead. The state's increased activity at this time is due to East Texas, the most active spot in the Union. Exceptional drilling activity should not be maintained in this area over a period longer than six months, unless extensions continue to be made, since wells are completed within three or four weeks.

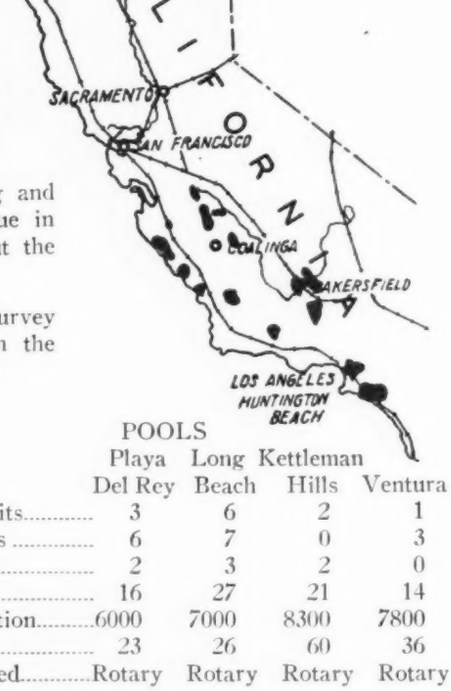
Texas had 501 new drilling permits, 413 completions, 206 rigs and 902 drilling wells to show for its activity during April.

Following is a tabular review of the state's active areas:

	POOLS			
	East Texas	Gray County	Van	Refugio
Number of Permits	151	3	13	2
April Completions	184	7	15	7
Number of Rigs	155	2	1	2
Number Drilling Wells	267	18	10	18
Gravity of Oil	40	42	36	26
Depth of Production	3600	2900	2600	6500
Type of Tools Used	Rotary	Rotary	Rotary	Rotary
Number of Casing Strings	2	2	2	3

CALIFORNIA

Production, 1930—228,612,000 Barrels



California had 31 drilling permits and 27 completions during April. The close of the month revealed 24 rigs and 305 drilling wells in the state. Heavy restrictions on drilling and production continue in force throughout the state.

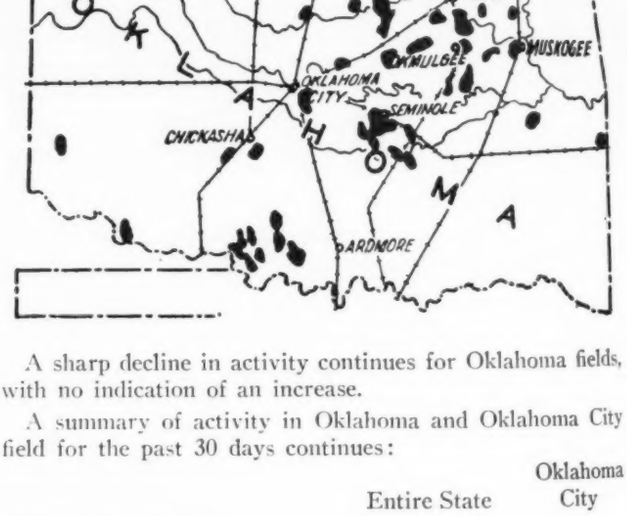
Following is a survey of operations in the most active fields:

	POOLS			
	Playa Del Rey	Long Beach	Kettleman Hills	Ventura
Number of Permits	3	6	2	1
April Completions	6	7	0	3
Number of Rigs	2	3	2	0
Drilling Wells	16	27	21	14
Depth of Production	6000	7000	8300	7800
Gravity of Oil	23	26	60	36
Type of Tools Used	Rotary	Rotary	Rotary	Rotary

*All statistics as of May 1st.
● Denotes oil and gas fields.

OKLAHOMA

Production, 1930—214,425,000 Barrels



A sharp decline in activity continues for Oklahoma fields, with no indication of an increase.

A summary of activity in Oklahoma and Oklahoma City field for the past 30 days continues:

	Entire State	Oklahoma City
Number of Permits	96	25
April Completions	97	25
Number of Rigs	65	26
Number of Drilling Wells	174	56
Gravity of Oil	36 (Average)	39
Depth of Production	Varies	6400
Type of Tools Used	Cab.-Rot.	Rotary
Number of Casing Strings	Varies	3

The gravity of oil produced varies in the state, but averages 36 degrees A. P. I.

"Union Wire Lines have been

giving Wonderful Service"

We have been informed that UNION Wire Lines have been giving wonderful service in Loving County, Texas—the same report that comes from practically every district where oil wells are drilled.

Above view is at the West Texas Petroleum Company's Allen No. 2, at Porterville, Texas; Eppenauer Drilling Company, contractors. The men, left to right: James McNear, mechanic; C. G. Nelson, tool pusher; W. H. Westmorland, driller, with Ole Nelson, C. G. Nelson's son; A. L. Sherman, tool dresser; Leonard Kilguen, driller; Dan Short, tool dresser; C. H. Curry, trucking contractor; W. E. Cunningham, Union Wire Rope Corporation

UNION WIRE ROPE CORPORATION, 3 N. Madison, Tulsa, Okla.

Oil Country Sales and Export Office:
338 Kennedy Bldg., Tulsa, Oklahoma

Branch Office and Warehouse:
Portland, Oregon

Parker-Abbott, Inc., Distributor,
582 Market St., San Francisco, Calif.

UNION WIRE ROPE CORP
TRADE MARK

Factory: 21st and Manchester,
Kansas City, Missouri

JARECKI MANUFACTURING CO.
Mid-Continent and Eastern Oil Field
Distributors . . . Stocks at All Stores

UNION WIRE LINES

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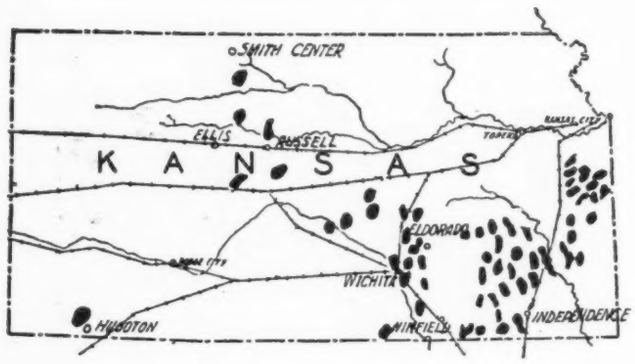
KANSAS—Production, 1930—41,745,000 Barrels



Kansas had 28 drilling permits, 31 completions, 48 rigs and 74 drilling wells last month. Both rotary and cable tools are used in the state, with the former predominating.

Following is a survey of the active Kansas fields:

	POOLS		
	Sedgwick County	McPherson County	Hugoton Field
Number of Permits	1	12	2
April Completions	1	9	6
Number of Rigs	1	22	6
Number of Drilling Wells	2	32	4
Gravity of Oil	36	37	gas
Depth of Production	2900-3250	2900-3400	2750
Type of Tools Used	Cab.-Rot.	Cab.-Rot.	Cab.-Rot.
Number of Casing Strings	2	2	2

ARKANSAS

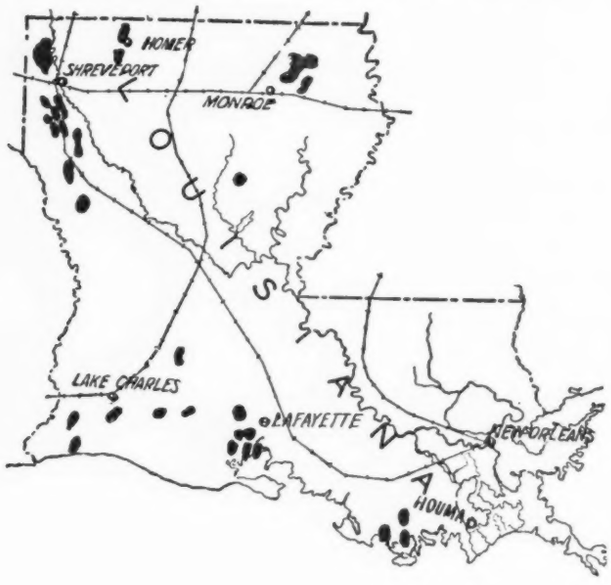
Production, 1930—19,680,000 Barrels

Summary of activity in the Arkansas oil fields the past month follows: One new drilling permit, 10 completed tests, 4 rigs and 36 drilling wells.

Rotary tools are used for drilling in the state, where frequent heavy gas pressures and soft, cavey formations are encountered.

LOUISIANA

Production, 1930—23,150,000 Barrels



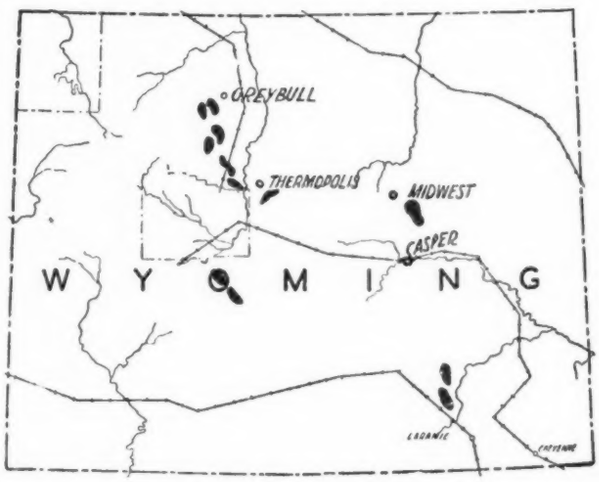
At the end of April there were 15 rigs and 95 drilling wells in Louisiana. During the month 39 wells were completed and 17 new drilling permits were issued. Rotary tools are operated in this state.

Mississippi, adjoining Louisiana to the east, had 11 completions last month, 4 rigs and 21 drilling wells. The play here is centered around Jackson.

WYOMING

Production, 1930—11,177,000 Barrels

There were 2 completions in Wyoming last month. The state has 8 rigs and 87 drilling wells. Both rotary and cable tools are operated here, with cable tool installations predominating.



●Denotes oil and gas fields.

NEW YORK

Production, 1930—3,825,000 Barrels

PENNSYLVANIA

Production, 1930—12,810,000 Barrels

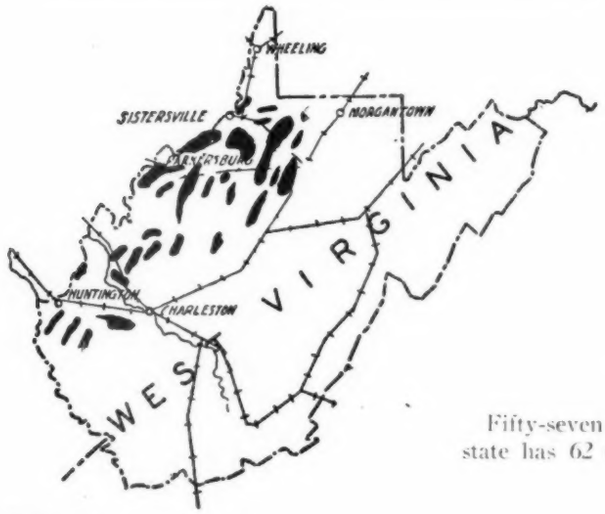
Pennsylvania showed 53 completions, 25 rigs and 61 drilling wells last month. The new Tioga gas field is the center of much interest.

New York had 11 completions during April. Wells in both states are drilled with cable tools.

ILLINOIS

Production, 1930—5,695,000 Barrels

Illinois had a total of 4 tests completed during April and at the same time had 3 rigs and 15 drilling wells. All of the drilling is done with standard tools, producing depths are shallow and no unusually hard formations are penetrated in reaching the oil-bearing formations.



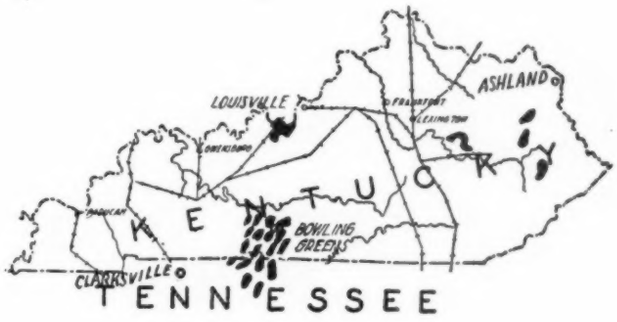
● Denotes oil and gas fields.

KENTUCKY

Production, 1930—7,300,000 Barrels

Kentucky had 134 drilling wells and 27 rigs in April. There were 80 tests completed last month. Tennessee reported no completions or new rigs and 17 drilling wells.

Drilling in both states is performed with standard tools.



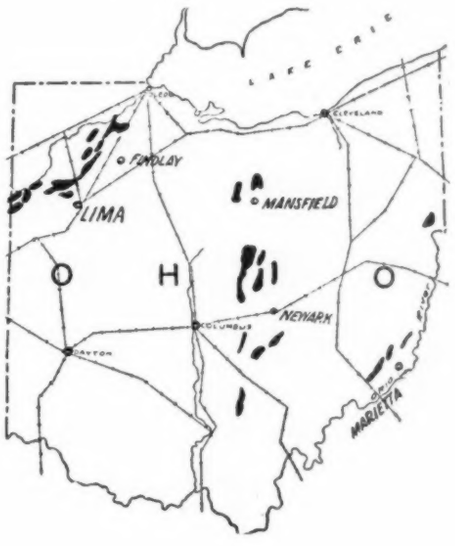
TENNESSEE

Production, 1930—20,000 Barrels

OHIO

Production, 1930—6,525,000 Barrels

There were 71 completions in the oil fields of Ohio during April. The state has 50 rigs and 151 drilling wells. Cable tools are utilized for drilling the wells.



WEST VIRGINIA

Production, 1930—5,100,000 Barrels

Fifty-seven wells were completed in West Virginia during April. The state has 62 drilling wells and 12 rigs. Drilling is done by cable tools.

IT'S A NEW SPUDDER ...but it has behind it 24 years of oil field EXPERIENCE

The assurance with which we present the Moore Type 10 Champion Spudder is based on our many years of experience in manufacturing oil field equipment. In addition, it has been thoroughly field-proven.

This spudder offers a convenient and inexpensive means of drilling shallow wells, cleaning out old wells to a depth of 2500 feet without the use of a derrick or standard rig front. It is light weight, portable and easily operated. A tractor, such as used on every lease, supplies the power and is used to haul the equipment from well to well.

Where a pumping derrick is erected over the well, Type 10-S Spudder is used. It is the same as Type 10 except that it has a stub frame to go under the bull wheel girt of the derrick.

LEE C. MOORE & COMPANY, Inc.
Established 1907
Pittsburgh · Tulsa
New York Offices: Oilfield Equipment Co., 30 Church Street, New York, N. Y.
Dallas, Tex. Wichita, Kan. Casper, Wyo. Shreveport, La. Houston, Tex.
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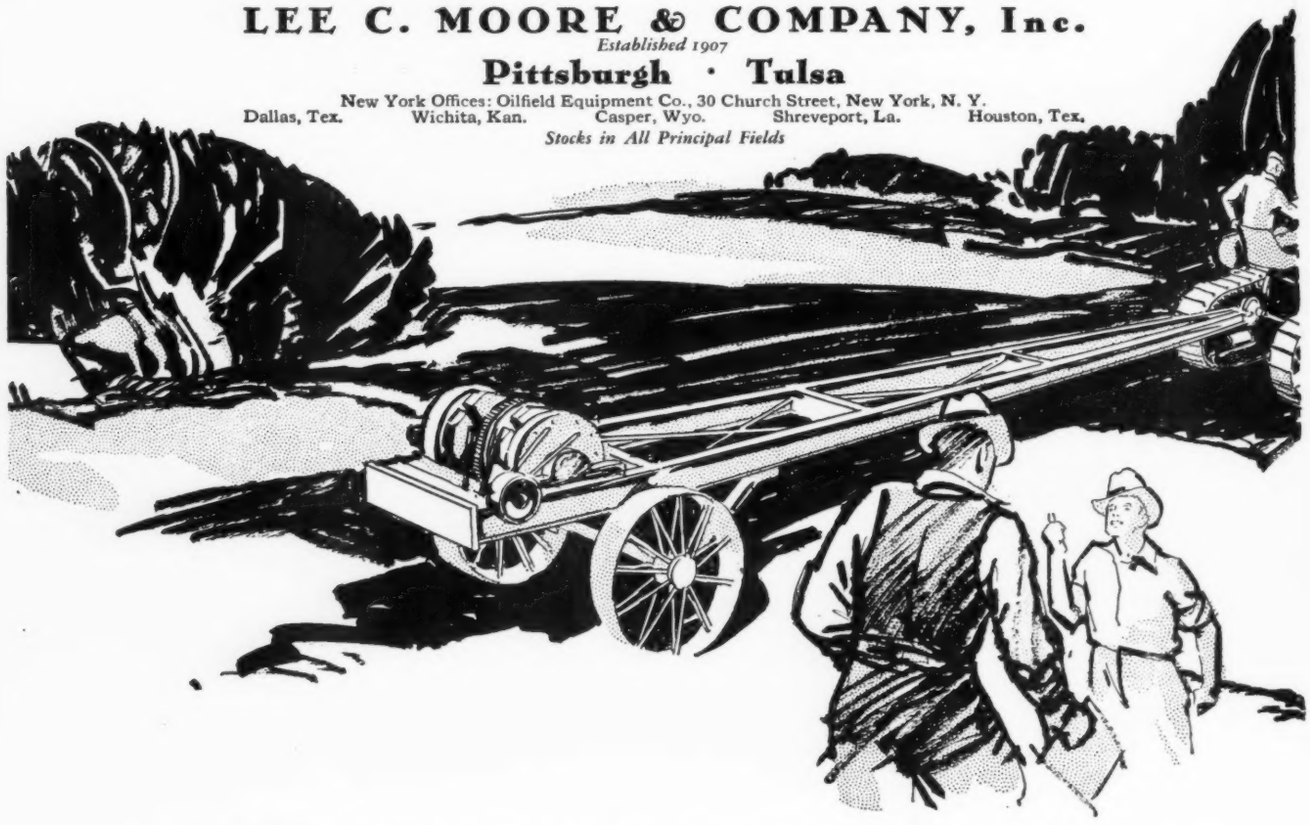
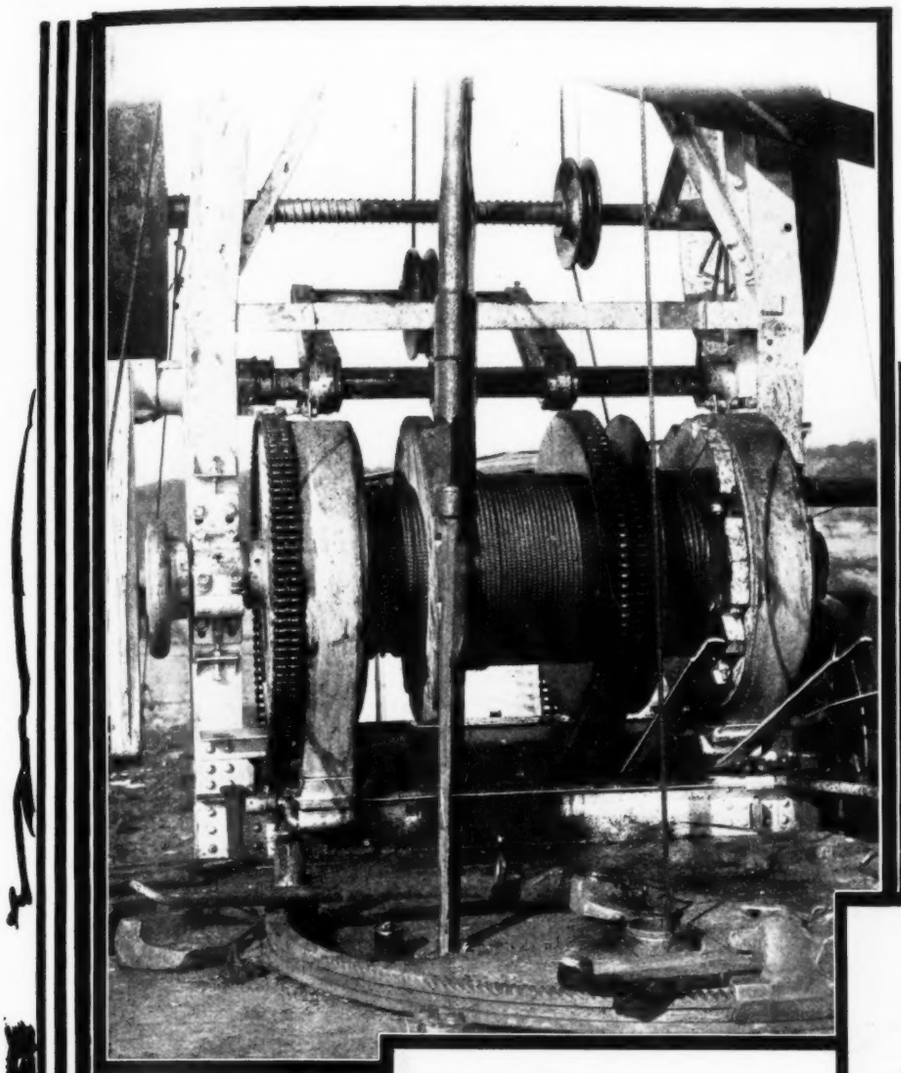
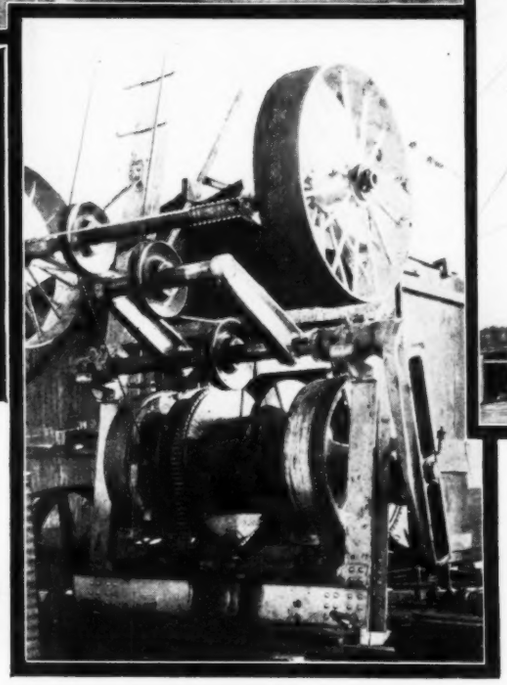


When writing LEE C. MOORE & CO., INC., *please mention The Petroleum Engineer*



Front View—The convenient location of the operating levers gives the driller constant control of the Moore Spudder.



Above—*A complete unit. Quickly set up, and easily powered and transported by a standard tractor.*

Left—*Rear View—An efficient drilling motion, comparable to that of a standard rig, is produced by the crank and spudding arm shown here.*

Moore Champion SPUDDER

When writing Lee C. Moore & Co., Inc., *please mention The Petroleum Engineer*

NEW MEXICO

Production, 1930—10,235,000 Barrels

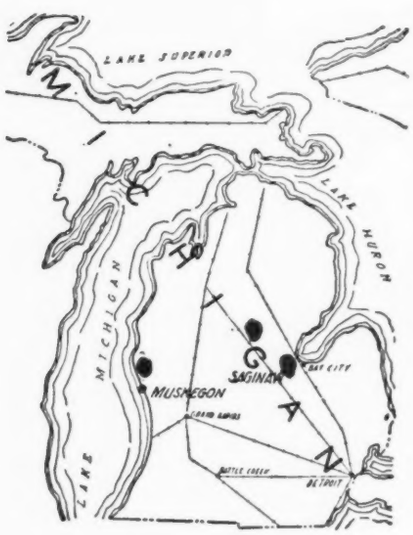
Activity in New Mexico continues to decline rapidly, there being 1 completion, 6 rigs and 48 drilling wells to represent oil operations during the month of April.

In the Hobbs field, which placed New Mexico in prominence during 1929, there are very few drilling wells. The lone completion of the month is accredited to this area. The decline is largely due to state restrictions on production and drilling operations.

Rotary tools were used in the Hobbs field, but many strings of cable tools are also to be found operating in New Mexico.

MICHIGAN

Production, 1930—3,525,000 Barrels



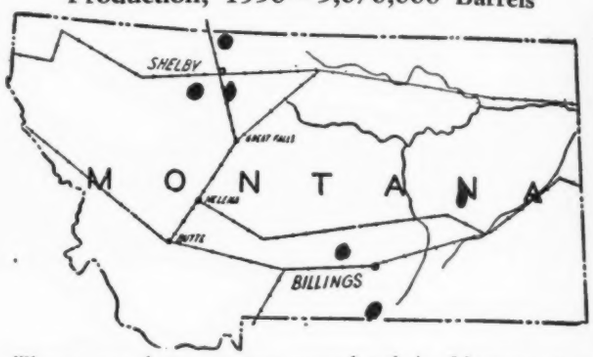
There continues to be a lull in the number of drilling operations in Michigan. During the past 30 days the state had but 1 completion. Ninety-nine wells are being carried on the active drilling list, and 43 rigs are listed for the state.

Practically all of the wells in the state are drilled with cable tools.

● **Denotes oil and gas fields.**

MONTANA

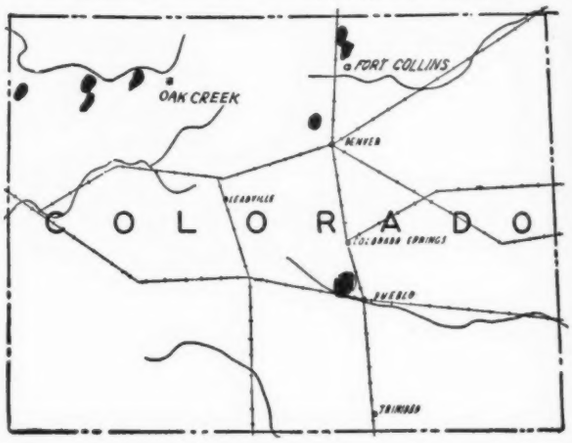
Production, 1930—3,070,000 Barrels



There was but one test completed in Montana during April, during which time the state had 10 rigs and 60 drilling wells. Cable tools are usually employed for drilling purposes.

COLORADO

Production, 1930—1,644,000 Barrels



Colorado had but 2 completions during the month of April. Drilling activity consists of 12 rigs and 74 drilling wells. Both rotary and cable tools are to be found operating in this state.

INDIANA

Production, 1930—1,000,000 Barrels

Indiana had 8 completed oil tests during the last 30 days. The state has 51 drilling wells and 3 rigs.

Cable tools are used by operators for drilling to the shallow depths in the state. There has been no unusually interesting development for several months.

KOBE SERVICE is of tangible value to the oil operator. It provides him with data, accumulated over a period of years, which definitely establish certain proved methods of obtaining maximum production from all wells and at the same time safeguarding the wells and the production therefrom.

KOBE SERVICE starts with a competent analysis of holes drilled and the oil sands penetrated. It determines the type of slotted pipe best suited to conditions in the well; the size, length and undercut of slots and the slot pattern which insure maximum drainage of the oil sands; eliminating guesswork or the hit-and-miss type of effort to accomplish this end. Kobe Service is available to you at all times without cost or obligation.

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Progress of Major Pipe Line Work

By J. H. DAMERON

GREAT LAKES PIPE LINE CO.

AS construction companies building the several major pipe line systems accelerate work with the aid of spring weather, several new major projects loom to hold the construction spotlight.

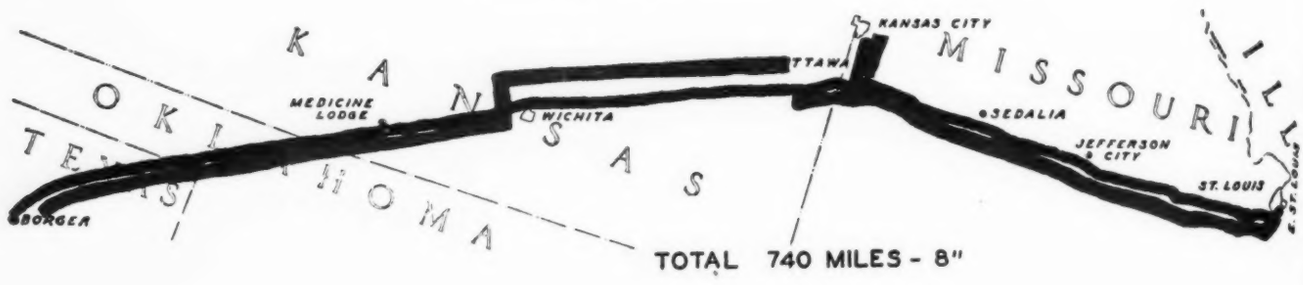
April witnessed the completion of two major trunk lines started last year and, simultaneously, announcements were made by two major companies of their intentions of constructing major systems this year.

In addition to these announcements, there are rumors of plans for other lines to be started in the near future. East Texas remains a lively scene for pipe line construction and several more projects originating in that prolific area will probably start soon.

Of the current construction projects, Great Lakes Pipe Line Co., a combination 6- and 8-inch welded gasoline line is running refined products of four refiners as far north as Kansas City, Mo. Southwestern Construction Corporation has completed its section on the south end and products of refineries at Tulsa, Okmulgee, Muskogee, Barnsdall and Ponca City are being pumped north to Kansas City. The stations on this line are powered with Diesel engines driving reciprocating pumps.

Contracts are expected to be awarded about May 10 for construction of the 115-mile, 4-inch lateral extending to Omaha, Neb. The last section of main line crossing Illinois to Chicago is well under way. With the exception of those located in Illinois, construction work on the northern stations is nearing completion. The Illinois station construction work is expected to begin about May 15. Terminal facilities at Kansas City, Mo., Des Moines, Iowa, and St. Paul, Minn., are near completion. The Chicago terminal work is scheduled to start May 15 and the Omaha terminal is expected to be started five days later.

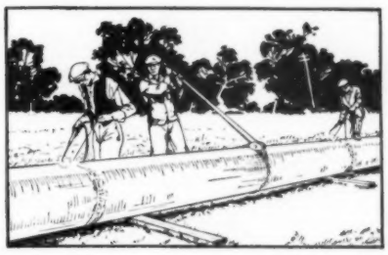
PHILLIPS PIPE LINE CO.



Kelly-Dempsey & Co., contractors, completed the 6-inch lateral from the Phillips Pipe Line Co.'s Borger, Texas,-St. Louis, Mo., 740-mile, 8-inch welded gasoline line to Kansas City, Mo., late in April. This completes the project with the exception of a short section near St. Louis, which will be completed early in May. Stations along the line, which have butane-fueled gas engines driving centrifugal pumps through increaser gears, are ready for service, and part of the line is in operation.

Indicates completed portion of line.
Indicates proposed route of line.

In the Mill and on the Firing Line



. . . LINDE PROCESS SERVICE ASSURES DEPENDABLE PIPE WELDS

IN construction of pipe lines in the field or double lengthing of pipe at the mill Linde Process Service can provide invaluable assistance in organizing welding operations for maximum speed, economy and dependability.

Step by step, from mobilization, training and testing of welders this service follows through to the final testing of the completed line. It effectively supplements the work of the customers' own engineers . . . . it focuses upon their problems the wealth of welding experience Linde has gained from two decades of pioneering in the pipe line field . . . . and it translates proved methods and well established laboratory findings into terms of actual field operation.

The predominant use of oxy-acetylene welding for laying pipe reflects the fundamental soundness of Linde Process Service and its assistance in obtaining ever-dependable welds. Every user of Linde Oxygen is privileged to call upon this service for assistance or advice. Write or telephone the nearest Linde District Office.

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Unit of Union Carbide and Carbon Corporation

126 Producing Plants UCC 627 Warehouse Stocks

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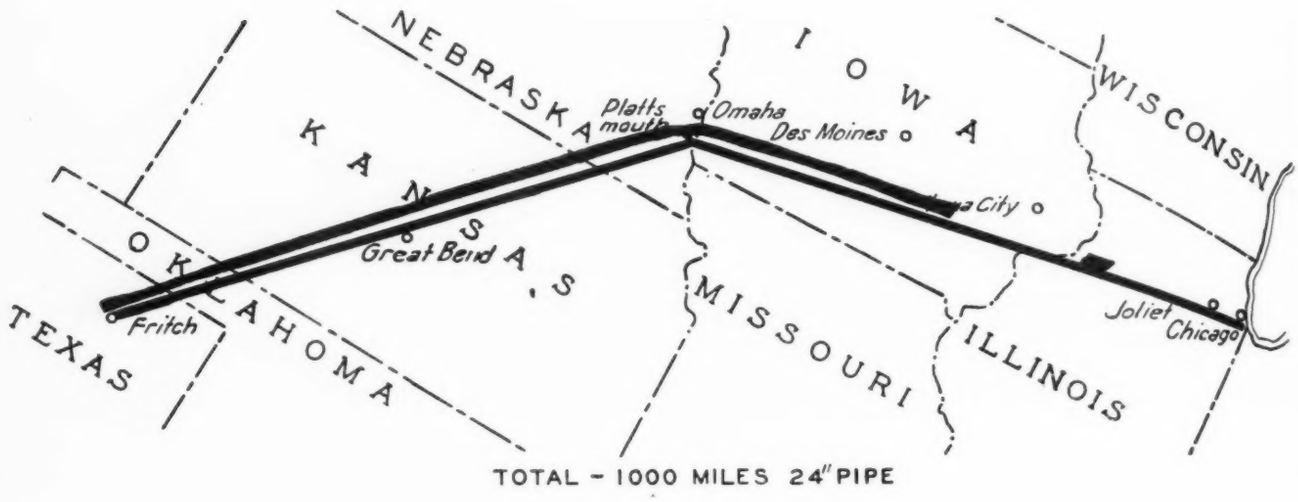
CONTINENTAL CONSTRUCTION CORP.



The Continental Construction Corporation is pushing on through Iowa with its 1,000-mile, 24-inch combination welded and coupled gas transmission line from the Texas Panhandle to Chicago. Oklahoma Contracting Co. has laid approximately half of its 100 miles of line through Iowa. Ford Bacon & Davis, Inc., through Williams Bros., Tulsa contractors, have five gangs working on the remainder of the Illinois section. The Missouri river crossing near Plattsmouth, Neb., has been completed and the six 12-inch lines comprising the Mississippi river crossing have been pulled across.

A total of 468 miles of the line has been tested, bringing the tested part of the line as far northeast as the Missouri river at Plattsmouth. Approximately 200 miles more of the line is in the ditch and ready for testing. Compressor station construction is progressing rapidly, with No. 1 station at Fritch, Texas, which will be the largest in the world, 10 per cent complete. Number 7 station is 60 per cent complete, while No. 8 is 40 per cent complete and No. 9 is 15 per cent complete. Work has just started on No. 10 station.

PANHANDLE-EASTERN PIPE LINE CO.

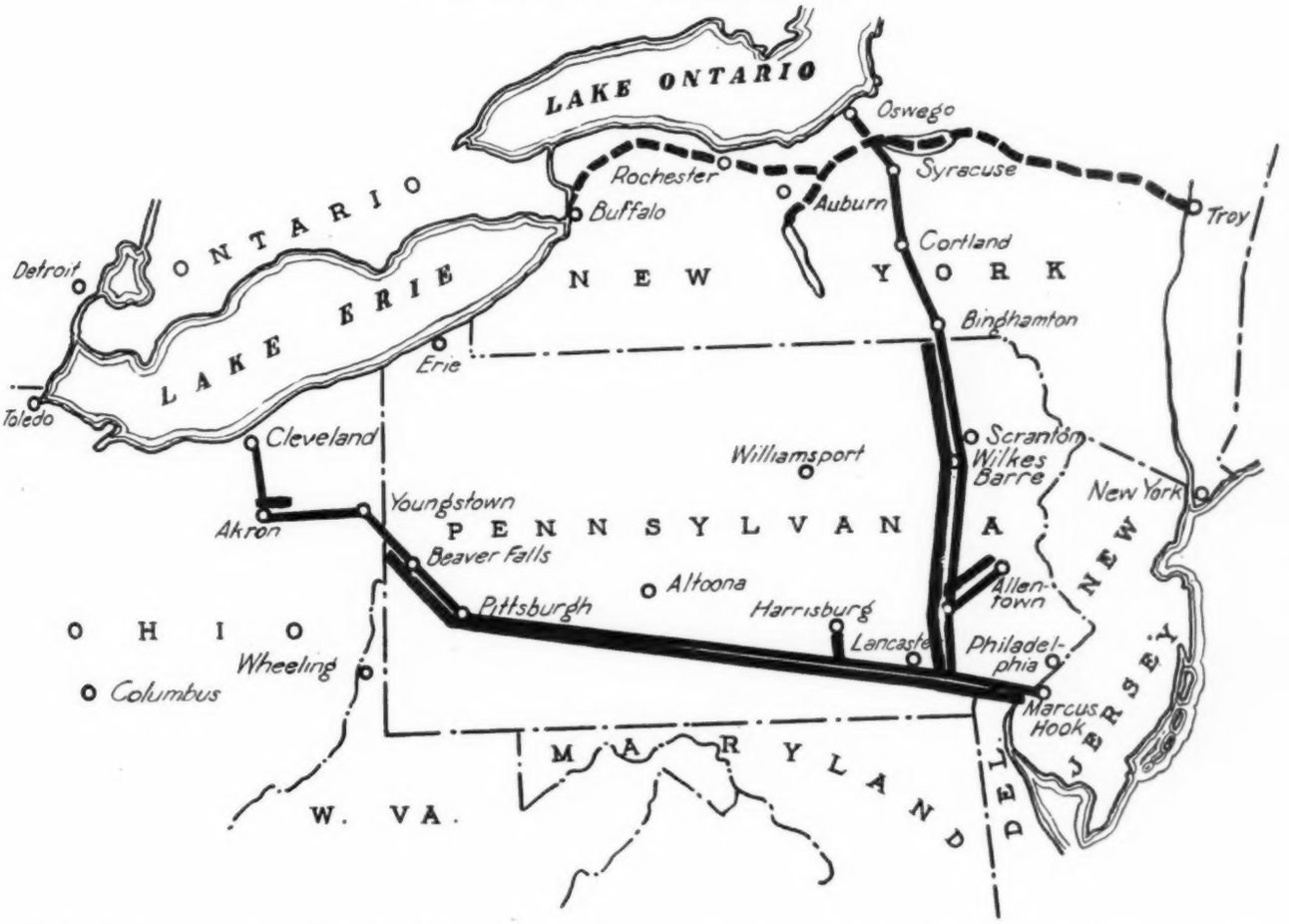
Panhandle Eastern Pipe Line Co., builders of the 24-, 22- and 20-inch system out of the Texas Panhandle to Indianapolis, Ind., has started construction in Illinois. The Mississippi river crossing was made by laying a 22-inch line on the side of a highway bridge near Louisiana, Mo. A double 18-inch, extending east for five miles, is being laid from the river through low land. Williams Bros., contractors, expect to start three gangs building the 22- and 20-inch through Illinois early in May.

Indicates completed portion of line.
Indicates proposed route of line.

GULF PIPE LINE CO.

With the completion of a 50-mile, 8-inch welded lateral running south from its main line to Cincinnati, Ohio, the Gulf Pipe Line Co. completed its 760-mile welded 10-inch Oklahoma-Ohio crude carrier late in April. The main line ties in to other oil lines at Spencerville, Ohio. This will permit shipment of crude oil to the east over the system.

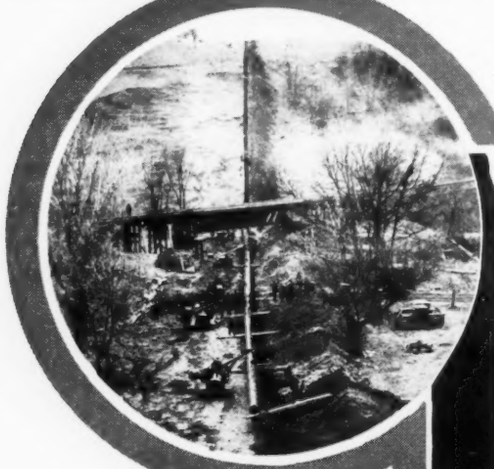
SUSQUEHANNA PIPE LINE CO.



In the East, Susquehanna Pipe Line Co. (Sun Oil Co. subsidiary) is nearing completion on its expansive gasoline line. Two construction crews are working on the east end, terminating at Cleveland, Ohio, and work has been resumed on the north end of the line, which terminates at Syracuse, N. Y. Part of this line was in operation during the past winter. The stations are equipped with centrifugal pumps driven by motors.

Indicates completed portion of line.
Indicates proposed route of line.

WHERE THE COUNTRY IS ROUGH, TRUMAN-SMITH FORGES AHEAD LAYING PIPE.....



Truman-Smith with their large army of skilled workmen and vast reserve strength of modern equipment finishes pipe line after pipe line in leak-proof condition across all kinds of country. No job is too difficult, nor can specifications be too rigid but what this firm can complete the work in less time. —the lowest bid is not always the cheapest.

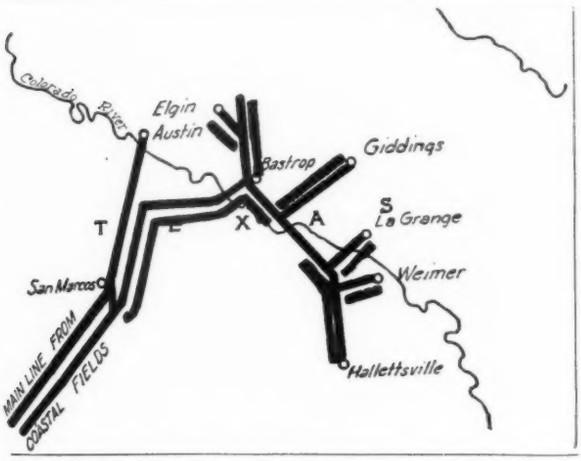
"The Truman-Smith way is the most economical in the long run"

The TRUMAN-SMITH CONST. Co.
EL DORADO, KANSAS.

SOUTHERN FUEL CO.

On the west coast the Southern Fuel Co. has part of the construction work on its 185-mile, 26-inch gas line from Kettleman Hills to Los Angeles and Long Beach under way. Contracts for the construction of the long section of the line will be awarded early in May.

Construction work is now going on in the Los Angeles area. Despite some of the mountainous country this line will traverse, construction work is expected to progress comparatively rapidly. The line will be welded, will cost approximately $7,000,000 and have a capacity of 130,000,000 feet of gas daily.



UNITED GAS CORP.

With most of its difficult construction work completed, the United Gas Corporation is nearing the finish line on its 420-mile welded gas transmission system through south Louisiana. Contractors on this line, F. C. Youmans Co. and Sexton Corporation, encountered numerous delays in going through swamps and rice fields. Additional compressor station capacity for this line, which will be fed by the main line running south out of Louisiana, has been completed.

The extension of the main line system north from the coastal fields to territory near Austin, Texas, has been completed and is in service.

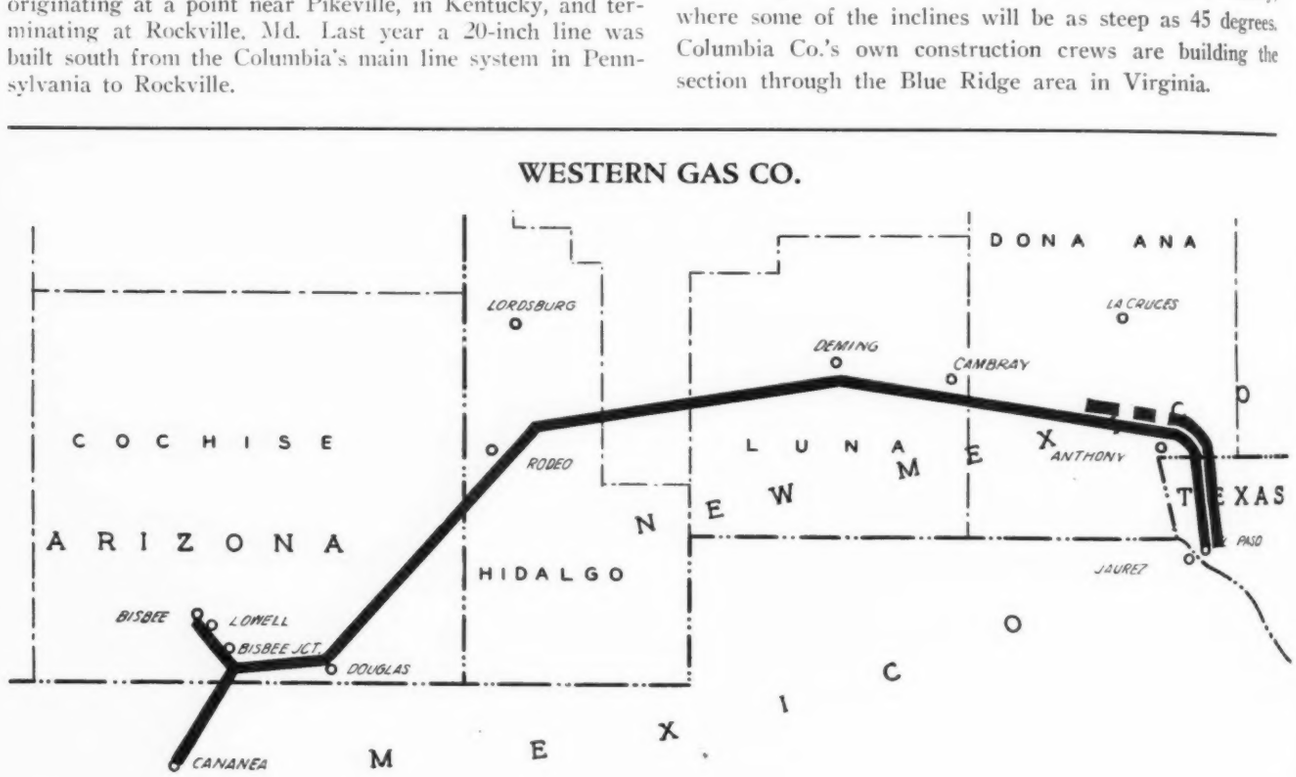
Indicates completed portion of line.
Indicates proposed route of line.

COLUMBIA GAS & ELECTRIC CO.

Columbia Gas & Electric Co. has started construction work on the west end of its 350-mile, 20-inch coupled line originating at a point near Pikeville, in Kentucky, and terminating at Rockville, Md. Last year a 20-inch line was built south from the Columbia's main line system in Pennsylvania to Rockville.

The west end of the line will offer the most difficult construction problems. It will traverse mountainous country, where some of the inclines will be as steep as 45 degrees. Columbia Co.'s own construction crews are building the section through the Blue Ridge area in Virginia.

WESTERN GAS CO.



With construction well organized and moving rapidly, Western Gas Co. expects to complete its 12-inch gas transmission line to Bisbee, Ariz., and Cananea, Mexico, by the latter part of June. Construction work is being done by Bechtel & Kaiser, Ltd., California contractors.

Practically all of the pipe for the line has been shipped and the four construction gangs have laid more than 50 miles of the line out of El Paso. Construction work is well along with two of the booster stations, and the other two have been started. The line will be fed by the El Paso Natural Gas Co.'s line running from Jal, New Mexico, to El Paso.

Indicates completed portion of line.
Indicates proposed route of line.

The Month's Activities *in* Refining*

By F. R. STALEY

REFINERY crude runs for all three divisions show a decided increase over last month.

Several new refineries are contemplated for East Texas. The Macmillan Refining Co. will construct a 7,000-barrel topping plant near Longview. Korie interests of Wichita Falls will build a 1,000-barrel plant at Gladewater.

The Simms Oil Co. of Dallas, will probably enlarge its Dallas refinery to run East Texas crude.

The Panhandle Refining Co. will construct a small topping plant near Graham, Texas.

The Continental Oil Co. purchased control of the Tonkawa refinery at Pyote, Texas. This makes a total of 12 refineries owned by the company.

The Altitude Petroleum Co. has resumed operations of the old Peerless plant at Chanute, Kans. Part of the plant will be rebuilt and improved.

The Arthur G. McKee Co. will build a 2,000-barrel refinery near Hanover, Germany. It will be a combination crude and cracking plant.

A 10,000-barrel refinery will be constructed at Buenos Aires. The construction was authorized by the provisional government at Buenos Aires.

The Pure Oil Co. will sell its refinery gases from the Toledo refinery to a glass plant at Rossford. A new pipe line will be constructed to transport the gas.

Many interesting technical papers were presented before the National Petroleum Association semi-annual meeting in Cleveland, April 23 and 24.

The American Society of Mechanical Engineers Refining Meeting was held May 5 and 6 at Elizabeth, N. J. A variety of papers on refining technology were presented. An inspection trip was made through the Standard Oil Co. (N. J.) plant.

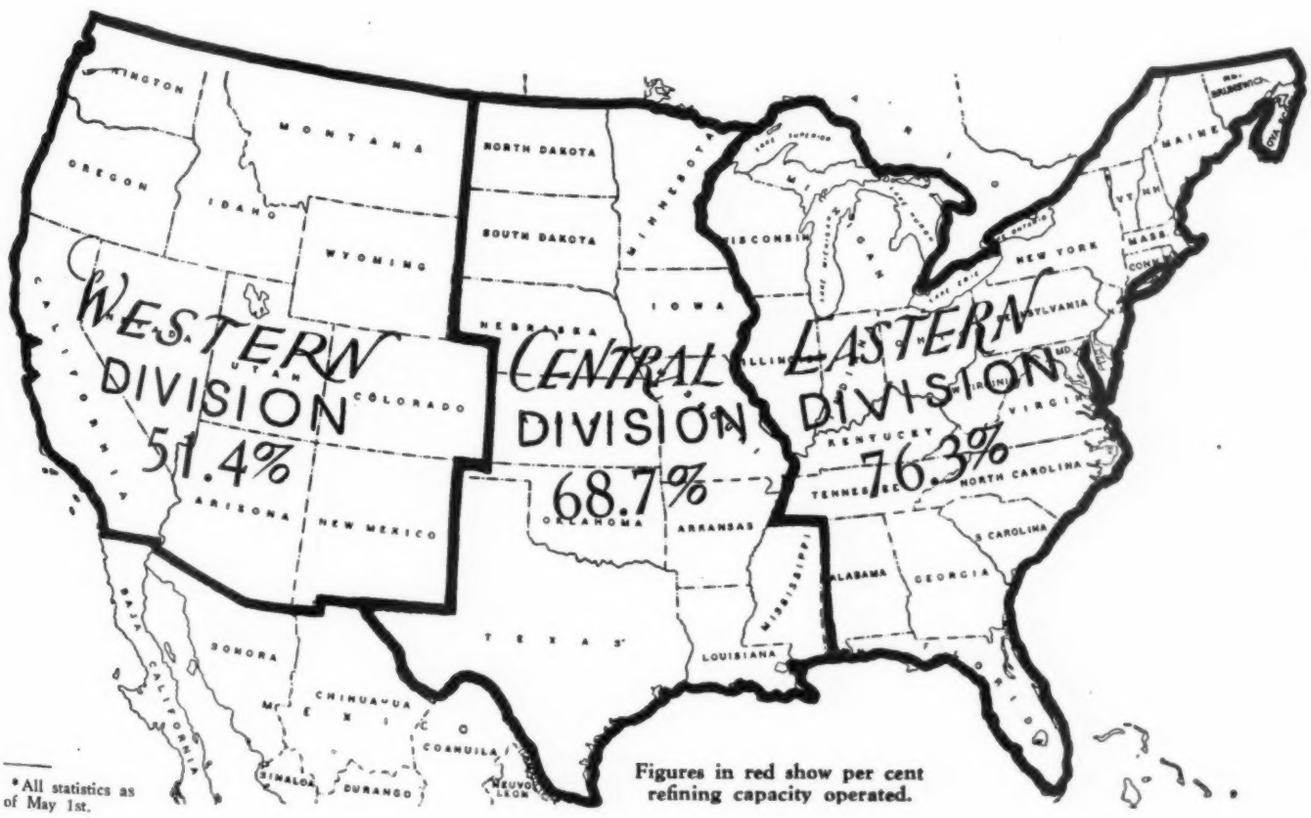
A high temperature symposium has been arranged by a joint committee of the A. S. T. M. and A. S. M. E. to discuss the effect of temperature on the properties of metals. Sessions will be held at the meeting of the A. S. T. M. at the Hotel Stevens, Chicago, June 23.

Natural Gasoline

Crosbie & Moran, Inc., will build a 2,500-gallon gasoline plant near Kilgore, Texas. This will be an absorption plant. Tests show an average gasoline content of the gas of two gallons per 1,000 cubic feet.

The high pressure gasoline plant recently put into operation at Sugar Creek, La., was built by the Stearns-Roger Mfg. Co. The plant was designed by the J. A. Campbell Co. of Long Beach, Calif.

A recent report of the U. S. Bureau of Mines shows a material over-production of carbon black in 1930, which has resulted in falling prices as the stocks continue to mount.



Figures in red show per cent refining capacity operated.

*All statistics as of May 1st.

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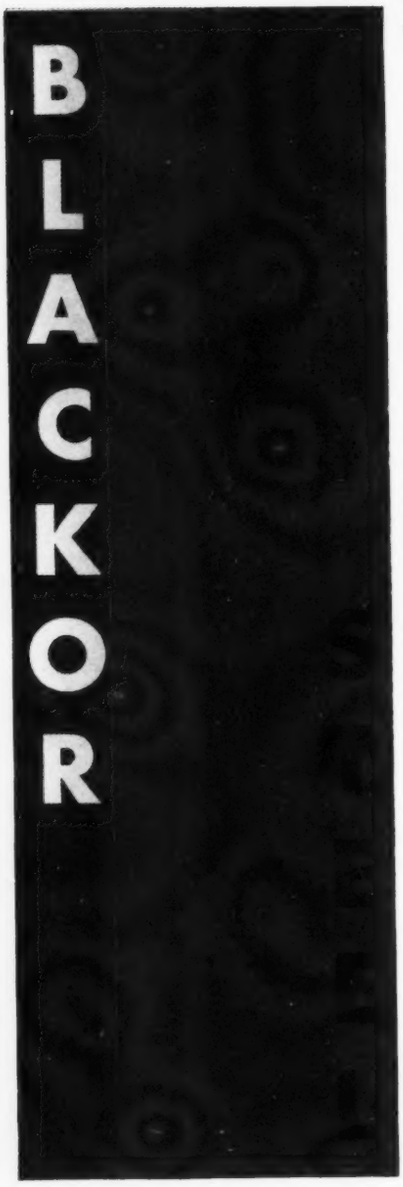

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River crossing on an Oklahoma gas line.

The IMPORTANCE *of a* Water Survey —*and* Analyses *for* Gas Companies

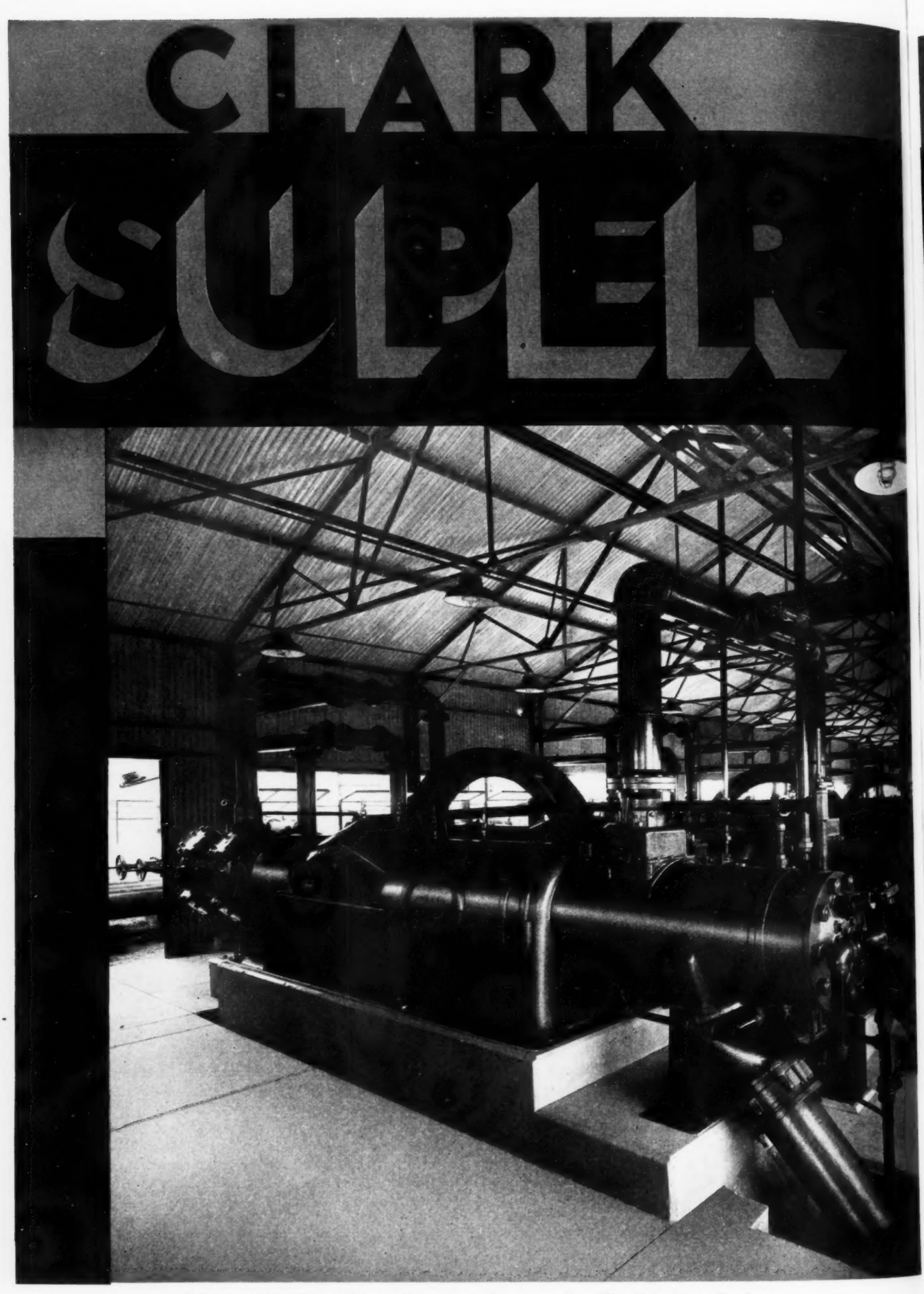
ROY PARKER, *Chemist, Oklahoma Natural Gas Corporation*

MOST oil and gas companies of today have safety teams especially trained in work that might in certain emergencies save a life. Posters are placed on bulletins boards so that employes will read helpful suggestions as to their well-being. These safety measures usually are concerned with some physical operation which the employe performs in his daily work, and to exercise the utmost care in all his work is the prime purpose of any posted reminder. Carelessness, resulting in injury, either to self, or a companion worker is cause for discharge with many companies and will not be tolerated. In our own vernacular, we say, "He knew better and was careless," but to be forced from your work and consequently your pay check, for some reason unthought of by yourself, and not suspected or investigated by your employer, is a fact and does happen. The water an employe drinks every day can be the source of far worse hazards than the pump station he operates, or the wells he tends. With this thought in mind, the writer will attempt to explain the work done in our laboratory, together with procedures and possible suggestions as to water surveys.

There are certain requirements relative to the source and protection of a water supply, as indicated by a survey and other requirements relative to bacterial content as shown by standard tests herein described. However, in view of the well recognized principle that the significance of bacteriological examination is somewhat variable due regard must be given a water source that conforms to other requirements of odor, taste, turbidity, chemical composition, etc. Confirming tests should be made since condemning a well usually causes much inconvenience and no small expenditure of cash. The chemist who makes the survey and conducts the examination will have to use considerable judgment in regard to all existing conditions. The writer condemned a cistern at one of our stations that, from every visible angle, seemed to have no chance to be polluted. There was a toilet some distance away, but at a lower elevation. Repeated tests showed B. Coli. A more thorough investigation proved the immediate underlying rock to slope directly opposite the surface strata. Cracks in the cistern cement told the story. Emptied and repaired, the cistern gave no more trouble. Chemical reaction of decaying manure generates some heat. I have seen this fact put to use, large quantities of manure being boxed around the well piping to prevent freezing. Almost invariably tests show this water unfit, a very high bacteria count being characteristic. Such practice, if the topography condition is suitable for drainage from some fecal source is especially dangerous. Shallow wells with probable intermittent leaks in the pipe casing will allow contamination.

At this season of the year, the precipitation is usually greatest. Spring showers start the small creeks running and the added surface moisture penetrates the ground to a considerable depth. In soil, and the fecal matter of privy vaults, the duration of typhoid germs is quite lengthy. A case is known where they lived fifty-two days. Germ multiplication probably won't take place, but they may be carried by water currents to a considerable distance from the point where they were first introduced. Contamination of wells and springs is thus brought about sometimes by the washing of bacilli out of soil in which they may have lain dormant for many weeks. Persistent water contamination is sometimes traced to such a soil contamination. The practice of using human excrement for manuring gardens entails a danger no less real because often unrecognized.

Springs are generally quite susceptible to contamination in spite of the good repute in which the average person holds them. Only those which arise from deep and extensive water-bearing formation can be considered safe, and even then their character should be proven by examination. Many



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of the large flow springs are such because of concentration and easy passage through limestone formations, which may be receiving unfiltered surface water or direct contamination.

A glass bottle of good quality of any size or shape may be used for the bacterial sample, provided it holds a sufficient amount to carry out all the tests that are required and is such that it may be properly cleaned and sterilized and will keep the sample uncontaminated until the analyses are made.

All sample bottles should be shaken vigorously before samples are removed for plating. Plating should be done immediately. One c. c. of the sample or dilution shall be used for plating, and should be placed in the Petri dish first. Ten c. c. of liquefied media at a temperature of 40° C. shall be added to the 1 c. c. of water in the Petri dish. The cover on the dish should be lifted only high enough to allow the introduction of the pipette or culture media and tubes used for pouring should be flamed. The sample and media should be thoroughly mixed by rotating and tilting the Petri dish. Plates should be solidified as quickly as possible, and placed in the incubator. Incubation should take place as stated herein, and a pan of water shall be placed in the false bottom of the incubator to saturate the air. In preparing the plates, such amounts of water should be used that will give between 30 and 300 colonies. 1 c. c. is usually quite satisfactory. Counting should be done with a lens of 2½ diameters magnification, 3½ X, with a focal distance of 3½ inches. Engravers' Lens No. 146, Bausch & Lomb Optical Co., is the correct lens.

When collecting samples, the following outline for a sanitary survey might be useful:

I. Open Wells.
   a. Depth of Well.
   b. Depth of Casing.
   c. Casing Flush with Ground.
   d. Character of Soil.
      1. Slope.
      2. Limestone Strata.
   e. Probable Source of Pollution.
      1. Open Toilets.
      2. Barns.
      3. General Sanitary Conditions.

II. Surface Waters.
   a. Same information as in I.
   b. History of Up-stream Water.
   c. Outlet So Placed as to Allow Time for Aeration.

The general procedure for obtaining samples follows:

A. From Faucet.
   Heat with a torch to kill any germ, might be placed by hand, then let run five minutes.

B. From Pump.
   Heat as from faucet.

C. Open Well.
   Sterilize bucket with Calcium-Hypochlorite and rinse in water to be tested. Then draw sample.

D. Precautions.
   1. Use sterile bottles, properly protected.
   2. Never lay stoppers or open bottles down.
   3. Never touch stopper or mouth of bottle to anything.
   4. Pack in special ice container, and examine as soon as possible. The sample should be tested the same day as collected. This is important, because of the rapid and often extensive changes which might take place in the bacterial flora of bottled samples, especially if temperature is above 10° C.

Following is test procedure:

The test for the presence of members of the coli-aerogenes group is thus dealt with in the following manner, as adopted by the Committee on Standard Methods:

It is recommended that the coli-aerogenes group be considered as including all gram-negative, non-spore-forming bacilli which ferment lactose with gas formation and grow aerobically on standard solid media.

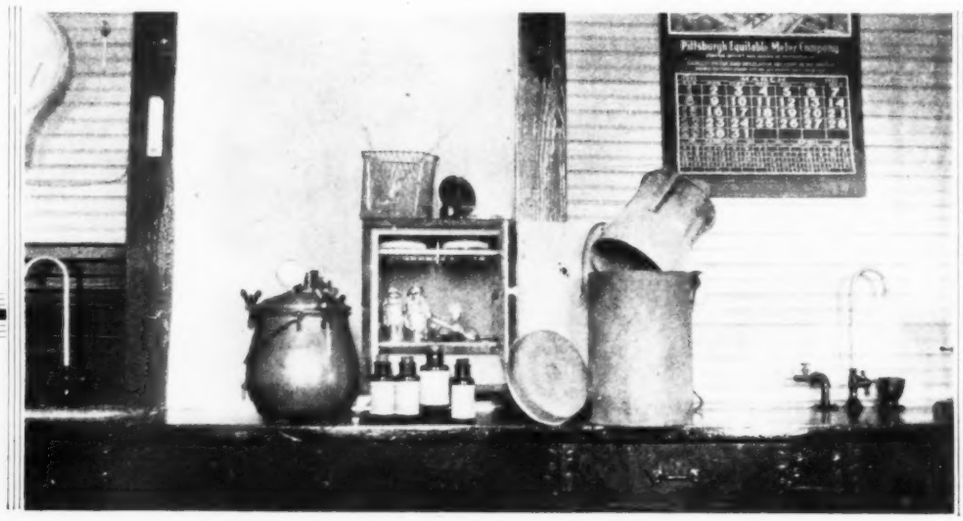
The formation of 10 per cent or more of gas in a standard lactose broth fermentation tube, within 24 hours at 37° C. is presumptive evidence of the presence of members of this group, since the majority of the bacteria which give such a reaction belongs to the group.

The appearance of aerobic lactose-splitting colonies on Endo or easin Methylene blue plates made from a lactose broth fermentation tube in which gas has formed, confirms to a considerable extent the presumption that gas formation in the fermentation tube was due to the presence of members of the Coli-aerogenes group. The germ multiplication on Endo will be observed when inspected, but there is a very noticeable cast or greenish sheen when B. Coli is present. By tilting the Petri dish so the light reflects on this particular area the green color is very noticeable. Use this portion of the culture to inoculate the lactose broth for complete test.

To complete the demonstration of the presence of organisms of this group, it is necessary to show that one or more of these aerobic plate colonies consist of non-spore-forming bacilli, which, when inoculated into a lactose broth fermentation tube, forms gas.

It is recommended that the standard tests for the coli-aerogenes group be either the presumptive, the partially confirmed, or the completed test as hereafter defined, each test being applicable under the circumstances specified.

When using the Presumptive test, inoculate a series of lactose broth fermentation tubes with appropriate graduated quantities of the water to be tested. When required to examine larger amounts than



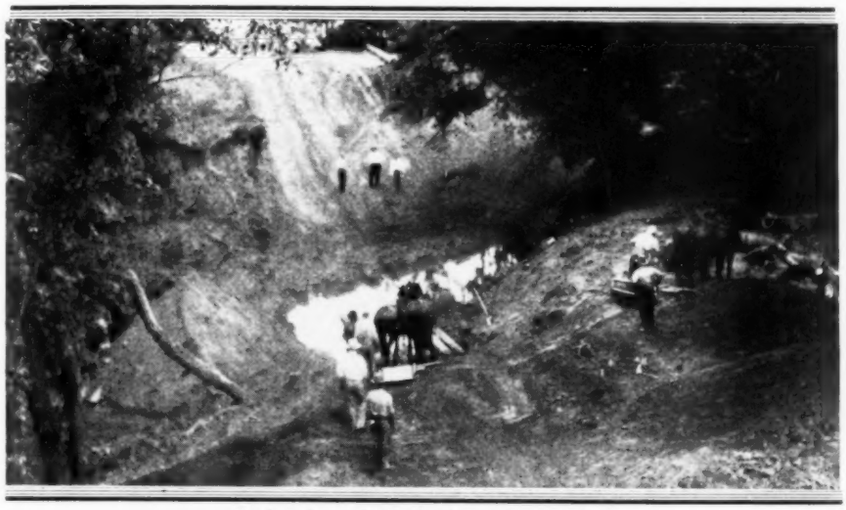
Field laboratory for making water tests.

10 c. c. as many tubes as necessary shall be inoculated with 10 c. c. each. Incubate these tubes at 37° C. for 48 hours. Examine each tube at 24 and 48 hours and record gas formation. The records should be such as to distinguish between:

1. Absence of gas formation.
2. Formation of gas occupying less than 10 per cent of the tube.
3. Formation of gas occupying more than 10 per cent of the tube. More detailed records of the amount of gas formed, though desirable for the purpose of study, are not necessary for carrying out the standard tests.

In the Positive Presumptive test, the formation of gas occupying more than 10 per cent is proof. The incubation is continued for 48 hours and the presence of gas in any amounts in such a tube at 48 hours constitutes a doubtful test. An arbitrary limit of 48 hours' observation doubtless excludes from consideration occasional members of the coli group, which form gas very slowly, but for the purpose of a standard test the exclusion of these occasional slow gas-forming organisms is considered immaterial.

For the partially confirmed test, make one or more Endo or eosin Methylene blue plates from the tubes which show gas formation from the smallest amount of water used. It is desirable to make these transfers as soon as possible after gas formation has occurred. If gas formation occurs at the end of 24 hours make transfers at that time. If at the end of 48 hours gas has formed in the tubes containing less of the sample of water than at 24 hours, transfers should be made from these tubes. For example, if the water has been tested in amounts of 10 c. c., 1 c. c. and 0.1 c. c. index numbers, and gas is formed in 10 c. c. and 1 c. c., not in 0.1 c. c., the test need be confirmed only in the 1 c. c. amount. Incubate the plates at 37° C. for 18 to 24 hours.



Cutting down the banks for a river crossing.

If typical colonies have developed upon the plate within this period, the confirmed test may be considered positive. If, however, no typical colonies have developed within 24 hours, the test cannot yet be considered definitely negative, since it not infrequently happens that members of the coli-aerogenes group fail to form typical colonies on Endo or eosin Methylene blue plates, or that the colonies develop slowly. In such cases, it is necessary to complete the test as follows, which is the completed test:

From the typical plates of the Endo or eosin Methylene blue plates made as prescribed above, fish at least two typical colonies, transferring each to an agar plate and a lactose broth fermentation tube. If no typical colonies appear upon the plate within 24 hours, the plate should be incubated another 24 hours, after which at least two of the colonies considered most likely to be organisms of the coli group, whether typical or not, shall be transferred to agar slants and lactose broth fermentation tubes. The lactose broth fermentation thus inoculated shall be incubated until gas formation is noted, the incubation not to exceed 48 hours. The agar slants shall be incubated at 37° C. for 24 hours, when a microscopic examination shall be made of at least one culture, selection of the one which corresponds to one of the broth tubes which has shown gas formation.

The formation of gas in lactose broth and the demonstration of gram-negative non-spore-forming bacilli in the agar culture shall be considered a satisfactory completed test, demonstrating the presence of the coli-aerogenes group. The absence of gas formation in lactose broth or failure to demonstrate gram-negative non-spore-forming bacilli in a gas-forming culture constitutes a negative test.

It is advisable to incubate uninoculated tubes and plates of all media along with the inoculated ones, to prove the sterility of all utensils and media.

The great majority of bacteria in water are killed by freezing, hence ice always contains but a fraction of the number in the water from which it was formed. Over 90 per cent, both of the ordinary water bacteria and of typhoid bacilli, die within a few hours, and a progressive decline in numbers then takes place, less than 1 per cent of typhoid germs surviving at the end of a week's freezing, according to experiments by authorities on water bacteriology. Ice stored for six months is practically sterile. Danger of typhoid infection from the use of ice in drinking water is always less than from the use of water from the same place. Bacteria of the kind discussed are not adapted to cold weather, which is a reason for being more suspicious of open water supplies in the summer season. If, after a sanitary survey and bacterial examination, the water is known to be unsafe for drinking purposes, the question arises as to ways and means of purification. Oftentimes, especially in cisterns, the source of pollution can be excluded. Even though the underlying area near a cistern is contaminated, the water contained in this reservoir can be drinkable if there are no places for germ admittance. Should there be defective places in the cistern walls, these must be made waterproof, tests made and water passed upon before recommended. Sterilization with hypochlorite of calcium can be affected before the original water is removed from the cistern. This reassures purification for the water that will be stored in the cistern later. Some companies have regular water wagons and cisterns are filled and replenished by this method, in which case the water can be treated conveniently. Should the source be a spring or well, in which the periodic supply is pumped to a tank, then sterilization can be done by the chemical application to water in this container. Of course every means should be employed to eliminate the source of pollution, but should this fail, and there is no other water available, treating must be resorted to. When sterilizing a water system, no part should escape attention. Tank, pipes, faucets, and all conveyors should come in contact with the purifying agent.

Methods of purifying water by chemical treatment are steadily increasing in use. Several chemicals have been

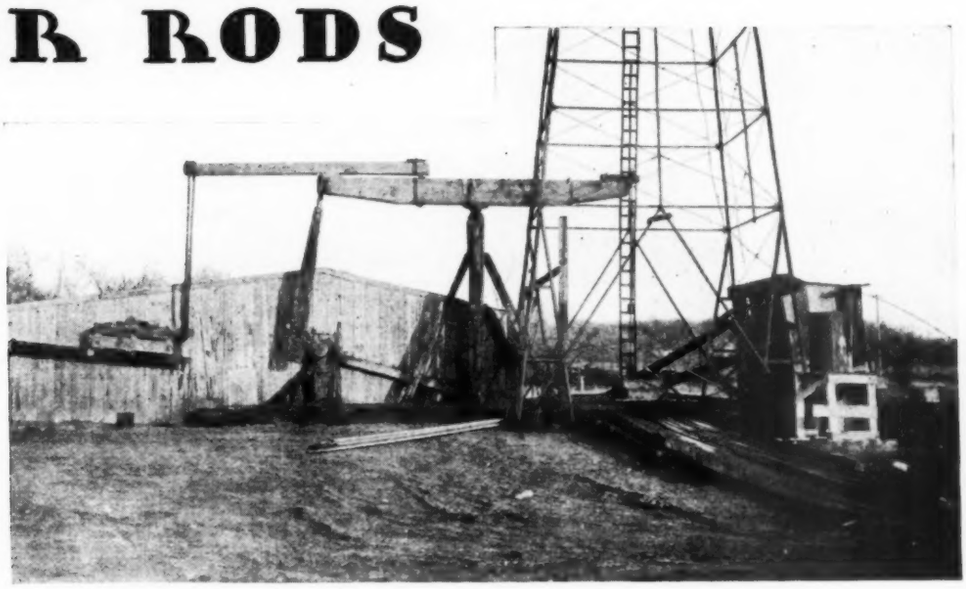
used from time to time, with considerable success. Liquid chlorine now seems to be the most effective purification agent. This is used in most larger municipal water systems. For small single reservoirs, such as cisterns, tanks, etc., hypochlorite of calcium is used. This chemical was used during the World War to make water drinkable, particularly on long marches, as the supply was taken from several sources, and if my memory of taste has not failed me, their idea of concentration was near saturation. Tests have proven, however, that water can be rendered harmless with the addition of hypochlorite of calcium, until a test indicates .3 to .5 parts per million of available chlorine. The qualitative test for chlorine in water that has been treated with hypochlorite, is to add a few drops of tolidin solution to a small portion of the water and observe the yellow coloration. This cannot be used in water that contains nitrites or ferric salts. To prepare tolidin solution add one gram of o-tolidin, c. p., to one liter of 10 per cent hydrochloric acid.

Drinking water surveys, examinations and purification are not necessarily limited to stationary supplies, such as those used by the attendants of a plant, power or station, but the work can be a safety measure in pipe line construction projects. The water supply source is ever changing when a gang of men begin construction. Today the water is hauled from one available source and in a day or so from somewhere else. The bacteriological effect of continuously changing drinking waters is bad enough, regardless of purity, but impure water can make it more disagreeable or dangerous. The degree of chance taken with water supplies varies with the means, and source of supply. Often not a great amount of thought is given this part of the construction scheme. A couple of large wooden barrels, a few buckets, several dippers, and a couple of men to act as water boys are all that seem to be necessary. The purity of the water dispensed isn't often considered. As the line progresses the water boys seek a new source, near the gang. The supply must be convenient, that is all. A long, dry summer like the one just past, adds to the danger, since many of the farm wells are low and permission to take water is denied. This causes the water boys to take any kind of water, from any kind of source, and that is what is often done. Barn-lot wells, creeks, etc., are where it is taken from. In a large per cent of the time, this water isn't fit to drink. An analysis will show a large count and the presence of B. Coli. If this condition must be tolerated, then the water should be treated chemically. This lessens the danger of typhoid fever. Hypochlorite of calcium added to a barrel of water until the test indicates .3 to .5 part per million will make the water safe to drink. The water boys can be supplied with the chemicals and proper instructions as to amounts to add. A disagreeable taste isn't necessary if the chemical is applied properly and the correct measured amount added to the water. Specially constructed tanks are sometimes used to furnish water to the gang. The gang usually numbers 200 to 300 men and many gallons of water are consumed in a single day. When tank trucks haul water it is in most cases pure, since the tanks are filled from some municipal supply that is treated and tested regularly. The barrels should be sterilized by allowing a solution of hypochlorite of calcium to remain in them for a day or so.

A drinking water survey might be made in conjunction with other surveys, right-of-way, soil, etc. Inquiries could be made at probable sources and samples collected, tested, and passed upon or rejected. Should a source be found impure, it would be safer to get water a mile farther away than to take a chance with the impure supply, and thereby jeopardize the health of several hundred men. Even though the impure supply might not cause them to be absent from work, the physical efficiency of many probably would be lowered. Men who don't feel at their best can't do the work they are capable and willing to do, and contaminated water can, and does, cause such a condition.

The water bucket on the line is often the cause of much trouble.

Heavy water wells mean nothing to JONES H.M. FULLY NORMALIZED SUCKER RODS



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Erection of the vacuum tower of a two-stage distillation unit in Russia. This unit has a capacity of 4,400 barrels of Grosny crude per day.

Modern Construction in Foreign

By JOHN C.

IN RECENT years most of the oil producing countries of the world have built new refineries or have expanded the capacities of their old plants. In some countries, notably Russia, this expansion has been very great. Many countries having no crude oil production have installed cracking units in order to produce a greater yield of motor fuel from the imported crude oil.

It is a tribute to American engineering skill in the industry that many of the units installed have been manufactured in the United States and erected by engineers from this country. Transportation and erection of equipment in some of the countries presented many difficulties, but these problems were usually solved very successfully. Native labor and artisans differ in various countries both in efficiency and skill. In some cases it is necessary to educate these men in the use of American tools and construction methods, but very frequently the native mechanics are extremely skillful.

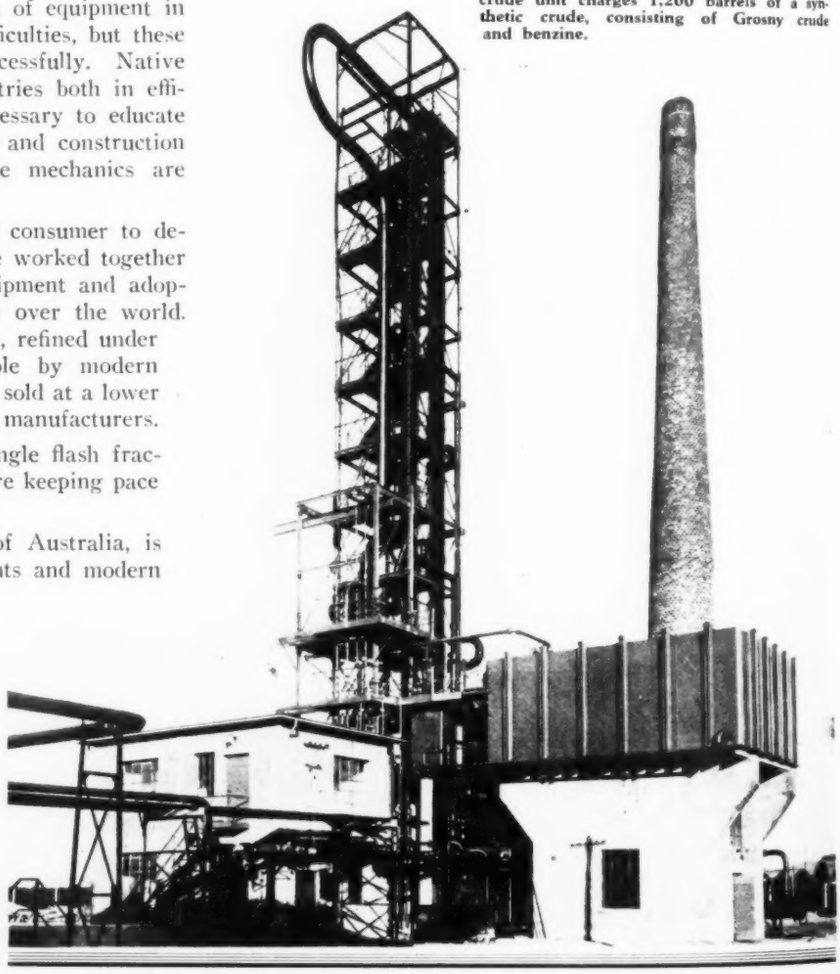
Keen competition and education of the consumer to demand the best in petroleum products have worked together to compel the installation of modern equipment and adoption of modern methods in refineries all over the world. It has been found that petroleum products, refined under the more efficient methods made possible by modern equipment, are not only better, but can be sold at a lower price and with a greater profit for the manufacturers.

American refineries were leaders in single flash fractional distillation, but foreign refineries are keeping pace with their American competitors.

Every continent, with the exception of Australia, is now equipped with modern cracking plants and modern distillation units. A world cruise taking in the modern refineries abroad, would give an American a liberal education. The first stop on such a cruise would be South America. A considerable percentage of the world's crude is now obtained from the Venezuelan and Colombian oil fields. Some of this crude is fractionated in South America before being exported to all parts of the world. However, due to legal situations, the crude is for the most part shipped in its natural state out of Colombia and Venezuela. A large quantity of crude is topped and cracked in the Island of Trinidad and in the West Indies before being sent to its place of consumption.

From South America and the West Indies a journey to foreign refineries would naturally lead to Europe, Great Britain being the first stop. Oil processed in England is imported from elsewhere, most of the oil having been topped in the fields where it was produced. The result is that

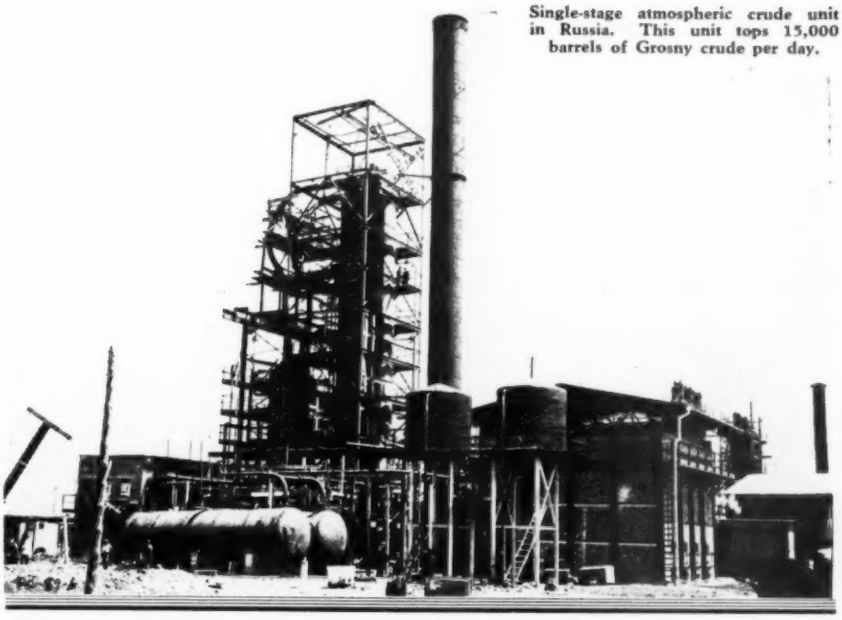
Koln, Czechoslovakia, refinery of the Vacuum Oil Company, A. Sp. This atmospheric crude unit charges 1,200 barrels of a synthetic crude, consisting of Grosny crude and benzine.



* Foster Wheeler Corporation.

Refinery Methods Countries

GLENN*



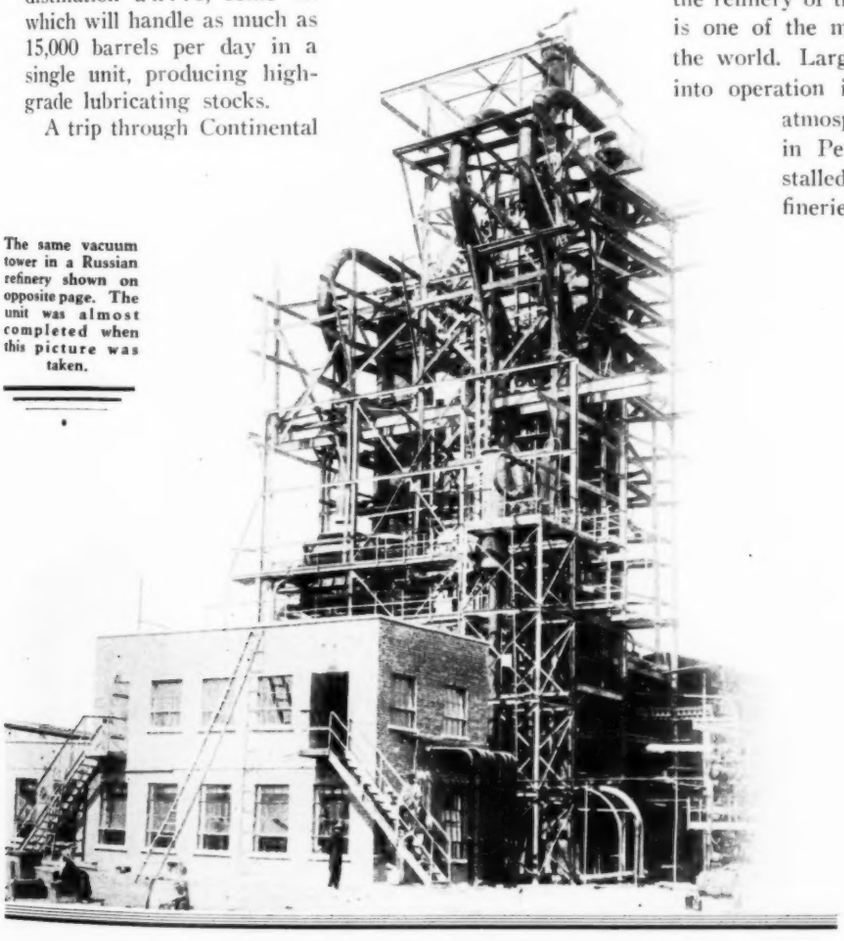
Single-stage atmospheric crude unit in Russia. This unit tops 15,000 barrels of Grosny crude per day.

refinery operations particularly specialized in are re-running and manufacture of high-grade lubricating oils.

From England modern refineries can be visited in nearly every country of Continental Europe. France is now building several large and modern distillation units. Germany, Austria, Hungary, Poland, Roumania and Czechoslavakia already have in operation single flash units for the manufacture of high-grade lubricating stocks from crude oil in one operation.

Russia, in an attempt to carry out the five-year plan, has built several large capacity single-stage and two-stage distillation units, some of which will handle as much as 15,000 barrels per day in a single unit, producing high-grade lubricating stocks.

A trip through Continental Europe would be brought to an end at Naples, where a modern re-running unit is in operation in the shadow of Mt. Vesuvius. Across the Mediterranean into Egypt one can visit the refineries where large cracking stills have just been put into operation.



The same vacuum tower in a Russian refinery shown on opposite page. The unit was almost completed when this picture was taken.

From Egypt regular airplane service is maintained to the Mesopotamian Valley and the Persian Gulf. Iraq, in the Mesopotamian Valley, and Persia are both well known for large oil production. Much of the oil produced in these fields is processed before being exported. This is done at the refinery of the Anglo Persian Oil Co. at Abadan, which is one of the most completely equipped and up-to-date in the world. Large gasoline cracking units are ready to go into operation in Iraq and many atmospheric crude and atmospheric re-run units are already in operation in Persia. The first modern tube still was installed in Persia four years ago and the refineries there have been growing in size and importance ever since.

Steamers from the Persian Gulf can carry the world traveler in comfort around India into Burmah where another modern two-stage atmospheric and vacuum distillation unit is now being placed into service. This unit has a capacity of 8,500 barrels per day of Burmah crude, which is reduced to several fractions, including gasoline at the top and heavy lubricating stocks in the lower range. There are several large refineries in the vicinity of Rangood, Burmah. All are modern and well equipped. Products from these have a large market throughout India.

The last stop in Asia, and also on the cruise, would be Japan, where several refineries process imported crude with modern equipment, including both two-stage distillation units and latest designs in cracking stills.

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It can be used on either a one or two standpipe hookup — the fluid flow being handled in any direction desired. Both standpipes can be closed at the same time.

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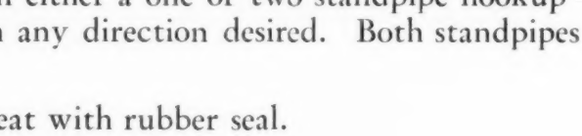

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Sucker Rods A. P. I. SPECIFICATIONS

By C. NORMAN BOWERS *and* BLAINE B. WESCOTT

THE standardization program of the American Petroleum Institute has accomplished much in bringing order out of chaos by the formulation of dimensional specifications which govern the manufacture of petroleum equipment and are presumed to make the products of one manufacturer interchangeable with those of any other. In the main, this objective has been accomplished with the result that the tasks of the purchasing agents have been lightened and the capital investments of oil companies in replacement stocks have been largely decreased. The progress thus far attained is attributable to the co-operative efforts of all concerned and should afford considerable satisfaction to those who have had a part in the program.

C. Norman Bowers.

Specifications controlling the purchase of materials are intended to insure products of a certain predetermined quality whether it be of material or workmanship. In order to fulfill their proper function, the limiting values should be such that the products can be economically manufactured and at the same time able to render service satisfactory to the users under normal working conditions. When agreement with these considerations has been established, the purchasers are justified in the exercise of whatever measures are necessary to secure material as specified.

Sucker Rod Specifications

The American Petroleum Institute Sucker Rod Specifications are among the most rigid thus far adopted and that alone is sufficient reason to make it a matter of interest to determine to just what extent the various manufacturers have endeavored to comply with the spirit of the standardization program. As originally adopted in 1926, the specifications allowed for tolerances based on Class 4 fit of the National Screw Thread Commission,[3] defined as follows: "The close fit class is intended for threaded work of the finest commercial quality where very little shake or play is desirable, and where a screw driver or wrench may be necessary for assembly. In the manufacture of screw-thread products belonging in this class it will be necessary to use precision tools, selected gages, and other refinements. This quality of work, should, therefore, be used only in cases where requirements of the mechanism being produced are exacting, or where special conditions require screws having a precision fit. In order to secure the fit desired it may be necessary in some cases to select the parts when the product is being assembled." It has been the almost universal experience of industry that quantity production of screw-thread products of Class 4 fit is highly impractical.

At the Eleventh Annual Meeting in November, 1930, the tolerances on pitch diameters of boxes and pins were increased 0.001 inch respectively, thereby removing the sucker rod thread from the Class 4, to the Class 3 fit. The definition of the National Screw Thread Commission for the latter is: "The medium-fit class is intended to apply to the manufacture of the higher grade of threaded parts which are to assemble nearly or entirely with the fingers and must have the minimum amount of shake or play between the threaded members. It is the same in every particular as Class 2, free fit, except that the tolerances are smaller." Boxes and pins are so designed as to provide a minimum pitch diameter clearance of 0.001 inch between the largest pin and the smallest box, and 0.007 inch maximum pitch diameter clearance between the smallest pin and the largest box.[4] Since according to the revised specifications, the pitch diameter tolerance is 0.003 inch, while that designated by the National Screw Thread Commission for 10 pitch American National coarse thread series in Class 3 fit is 0.0045 inch, it is apparent that the sucker rod thread is intermediate between Classes 3 and 4 and is still very close to the latter fit.

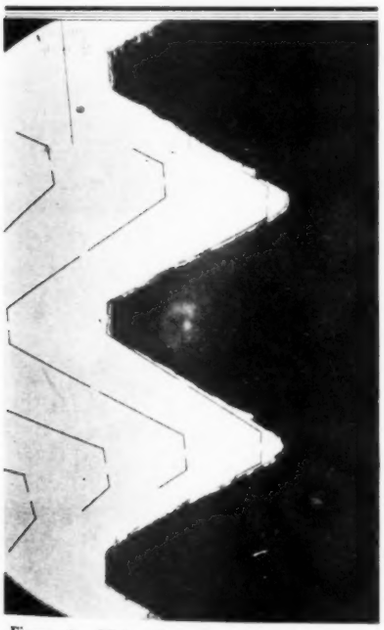

Figure 2. Make C sucker rod pin thread showing excessive angle error, lead error and thread height.

The Effect of Errors in Machining

The sucker rod specifications do not set limiting tolerances on lead and thread angles although errors in either consume a portion of the allowable pitch diameter tolerance. The effects of such errors are summarized in Table 1.

The tolerances in pitch diameter of

Figure 3. Make F sucker rod pin thread of exceptionally poor form, very great lead error.

[1]Materials Engineering Division, Gulf Research Laboratory, Pittsburgh, Pa.

[2]Engineer of Tests, Gulf Research Laboratory, Pittsburgh, Pa.

[3]Report of the National Screw Thread Commission, Miscellaneous Publication Bureau of Standards, No. 89.

[4]Supplement No. 1 to A. P. I. Standards No. 11-B, "A. P. I. Sucker Rod Specifications," February, 1931.

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In addition to Chapman Valves, Taubman Supply Corp. is factory representative for Republic Electric Weld Pipe, Pittsburgh Seamless products, Stockham Fittings and Edward Valves.

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This article (which is the second of a series on Sucker Rods) contains many interesting facts concerning this important item of petroleum equipment.

0.003 inch specified for sucker rod boxes and pins include all errors of lead, angle and pitch diameter. A consideration of the figures in Table 1 indicates that every 0.001 inch lead error per length of thread engaged consumes 0.0017 inch in the pitch diameter tolerance and that a lead error of 0.0017 inch on a sucker rod box or pin consumes the entire pitch diameter tolerance. In a similar manner a constant half-angle error of 1 degree and 9 minutes will also consume the entire pitch diameter tolerance. The full tolerance can not, therefore, be used on pitch diameter unless the lead and angle of the threads are perfect. If lead and angle errors both exist to the amounts tabulated, the pitch diameter of a pin, for example, must be reduced to the minimum limit of tolerance in order to pass a "go" ring gage test. A pin with greater combined lead and angle errors than those tabulated could not pass a gage test unless its pitch diameter were below the minimum limiting tolerance. Similar reasoning applies to boxes.

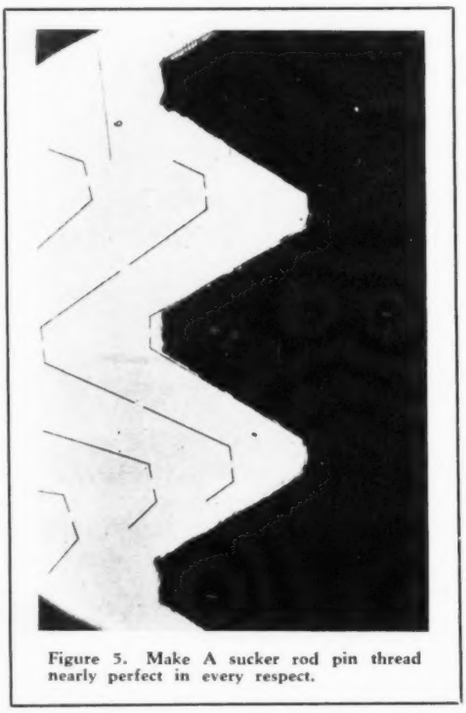

Figure 5. Make A sucker rod pin thread nearly perfect in every respect.

Gages and Gaging

Grand Master and Reference Master gages, consisting of complete sets of "go" and "no go" ring and plug gages with their respective mating plugs and rings, have been provided to insure the accuracy of workmanship desired. The choice of production or working gages is left to the preference of the manufacturer and the only condition imposed is that each manufacturer must be provided with a set of Reference Master Gages "tested by the U. S. Bureau of Standards, Washington, D. C., or by the National Physical Laboratory, Teddington, Middlesex, England, often enough to insure correct standards."[5]

Figure 4. Make B sucker rod pin thread with large angle error.

Ring and plug gages reveal the net accumulative total of errors in lead, angle and pitch diameter but do not indicate either the nature or extent of the inaccuracies present. The length of thread engagement has a very decided influence on the results obtained from their use and the manufacturer who desires to protect himself from the possibility of rejection must utilize working gages with full thread engagement.

Roll thread snap gages offer several important advantages over ring working gages for sucker rod pins; they require less gaging time since they are both "go" and "no go" gages at one and the same time, they can be so constructed as to check the taper in pitch diameter and, most important of all to the manufacturer, they disclose all errors of lead, angle and pitch diameter singly and collectively, throughout the full length of perfect threads. They are not suitable, however, for checking the imperfect threads and stand-off from the face of the shoulder. The gaging of sucker rod pins is readily carried out and offers no difficulties to the manufacturer using both ring and roll thread snap gages, the former periodically, and the latter on every product pin.

The gaging of boxes and couplings is a much more serious problem. Plug gages provide the only workable inspection method and must be used in spite of their manifest limitations. Consistent results are possible, however, with modern threading machines equipped with lead screws and employing ground thread taps. The quality and perfection of workmanship of the threads of boxes and couplings form a basis for judging the sincerity of purpose of the individual manufacturers since the inaccuracies are much more difficult of detection.

Figure 7. Make C sucker rod box thread with large angle and lead errors and poor form.

A. P. I. Gaging Tests

Manufacturers will incur serious risk of wholesale rejections by the use of any system of gages or gaging practice which does not provide

[5] A. P. I. Sucker Rod Specifications, Fourth Edition, January, 1930.

DID YOU EVER SEE ANYTHING SIMPLER?

TO APPLY—Simply lay tong *on top* of pipe and hook chain around it.

"MAKING UP"—Engage rear teeth and push down.

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for periodical inspection with full thread A. P. I. gages. This contingency is very forcefully illustrated by the results of tests made on representative samples of the principal makes of sucker rods. In some cases the rods were selected from stocks of distributors and in others they were selected from manufacturers' warehouse stocks. The working gages that were used provided for full thread engagement and were checked against reference master gages immediately before the tests. The results are summarized in Table 2.

The original series of samples was made up of twenty-three rods from six different manufacturers and a total of thirty-two pins and twenty boxes and couplings were gaged — not a single pin, box or coupling approached acceptance by the approved methods of gaging designated in the A. P. I. specifications. It is clear from a study of Table 2 that the pitch diameters of all pins of makes C, D and E, and part of those of make F, were very badly tapered; the average taper was 0.0056 inch from the first perfect thread to the last perfect thread, or nearly three times the allowable tolerance. The pitch diameters of make D at the middle of the pins averaged 0.0014 inch less than the minimum value specified (0.9950) at the time the rods were manufactured while those of make E averaged 0.0009 inch more at the middle of the pins than the maximum value specified (0.9970). Of all the pins examined, only three of make D were able to pass the "go" ring gage and these were undersized in pitch diameter and so badly tapered that they entered the "no go" ring gage at least five and one-half turns. The pins of makes A and B were uniformly much less tapered than their competitors and their pitch diameters were within the specified limits, but they still failed to pass the ring gage tests for reasons that will be later apparent.

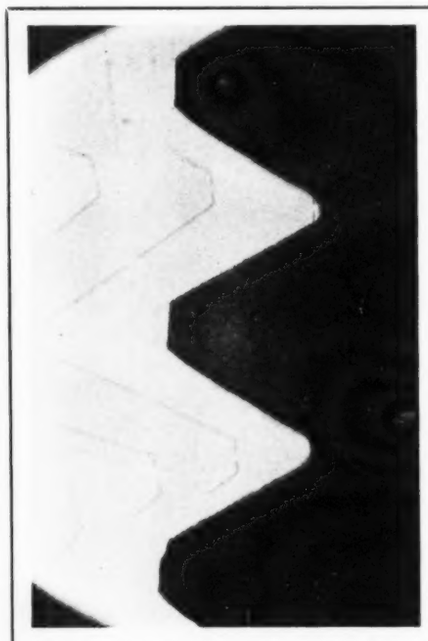

Figure 8. Make D sucker rod coupling thread of good form, small lead error but slightly too deep.

Figure 9. Make B sucker rod box thread with large lead error and too great depth.

As indicated in Table 2, three additional pins each of makes A and B were obtained for similar tests; those of make A were threaded on an automatic machine with a lead cam and using ground thread chasers, those of make B were threaded on an automatic machine with a lead screw. All six of these samples were made in the ordinary routine of plant production and received no special attention. The pitch diameters were all within the specified limits with the exception of the end of one make B pin. The three pins of make A did not allow the "go" ring to approach the shoulder face close enough to prevent the entrance of the "no go" feeler gage; they averaged 0.078 inch above the "no go" limit of 0.156 inch specified. Two pins of make B successfully passed the ring gage tests but the third pin failed to pass the "go" ring gage.

Without exception all boxes and couplings that permitted the entrance of the "go" plug gage also allowed the "no go" plug to enter completely. Those that gaged properly with the "no go" plug gage did not accept the "go" plug gage.

Micrometric Examination of Pins

It was pointed out in the previous discussion of gaging that ring and plug gages do not indicate the nature or extent of the errors present. Because of the positive manner in which all of the full sucker rods failed in the standard gaging tests, one pin and one box or coupling of each make were selected for complete examination with a thread measuring microscope. The samples selected for this purpose are indicated in Table 2. The instrument used was a Zeiss Toolmakers' Microscope which read directly to 0.0001 inch and allowed estimated readings with an accuracy of $\pm$0.00001 inch. Two interchangeable heads were used, one of which contained templates of perfect thread forms for U. S. Standard Threads of various pitches and the other contained cross lines for measurements of any nature desired, including the determination of thread angles with an accuracy of $\pm$10 seconds. Photographic records were made through the eye piece of the microscope at a magnification of thirty diameters. The microscope and camera in position for photographing are shown in Figure 1.

The pins were prepared for examination by the accurate location of centers for suspension between the anvils on the stage of the microscope. Table 3 illustrates in detail the data assembled from the examination of one pin; similar measurements were made on all pins that were selected for the purpose as noted in Table 2. The summarized results from all pins thus examined are given in Table 4.

Space will not permit more than passing mention of the more important points brought out by this study. In all cases the true

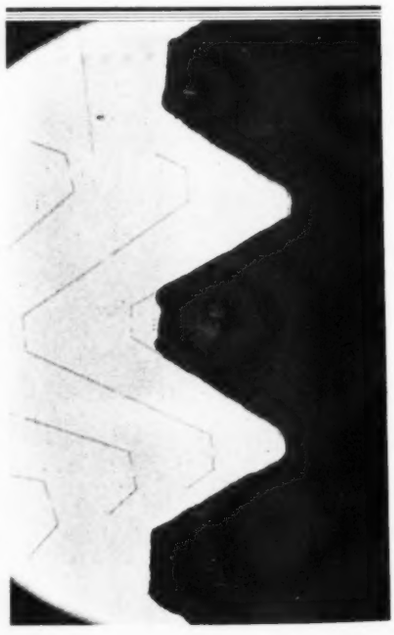

Figure 10. Make F sucker rod coupling thread with very small lead error, slight angle error and proper depth.

pitch diameter measured with the microscope was less than the effective pitch diameter measured with thread micrometers; this is consistent since the latter includes errors in lead and thread form while the former does not. With the exception of the one pin of make A, which will be considered separately, the minimum lead error found was 0.0018 inch and this is sufficient to consume 0.003 inch or the total tolerance in pitch diameter of the newly revised specifications. Lead errors of more than four times this amount were noted in the pin of make F. Although it would be instructive to discuss errors of angle and other deviations which form just as flagrant violations of the specifications it is not even remotely necessary to do so in order to explain the results of the gaging tests given in Table 2.

The two pins of make A included in Table 4 present a very striking contrast between what was and what is the practice of a manufacturer intent on the production of truly A. P. I. sucker rods. The pins were both made on the same type of automatic threading machines but the one in the first column was made with cut chasers and no lead device while the pin in the last column was made with ground chasers and a lead cam. In the latter pin particular attention is directed to the agreement between pitch diameter measured by the two methods, almost perfect lead and thread angles, and general agreement with specified dimensions. What was accomplished in this case is possible in other cases with the exertion of properly directed and intentioned efforts.

Typical illustrations of good, bad and indifferent threads on the pins examined are given in Figures 2 to 5, inclusive.

Micrometric Examinations of Boxes and Couplings

The boxes and couplings were prepared for thread measurements by turning a narrow collar on each end having a definite diameter and being accurately concentric with the axis of the box threads. Close fitting caps with centers coinciding with the axis of the threads served for mounting in the microscope. The boxes were then machined nearly to the center or pitch diameter line and the final metal removed by light lapping to prevent the formation of burrs. It should be noted here for future reference that any variation from the absolute pitch diameter line would give values less than the true pitch diameter of the product. The outside diameters of the boxes and couplings were accurately determined before and after preparation for examination and in no case was any distortion of the sample found as a result of the work done. Figure 6 shows a pin, box and mounting caps used for holding the box in the microscope.

The examinations of the boxes and couplings were carried out in the manner described previously for the pins. Table 5 typifies the measurements made on the individual products and a summary of all tests is given in Table 6.

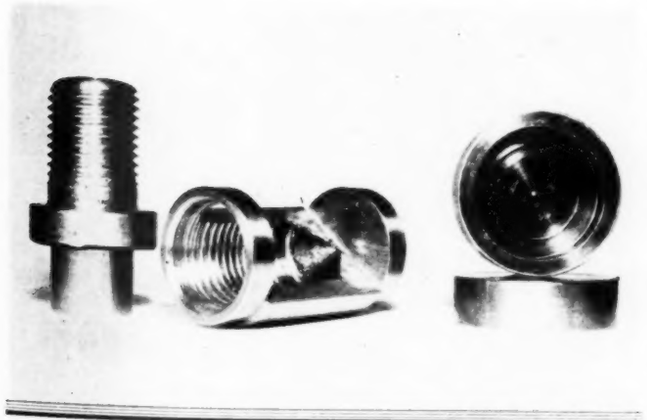

Figure 6. Box and pin samples prepared for micrometric thread measurements.

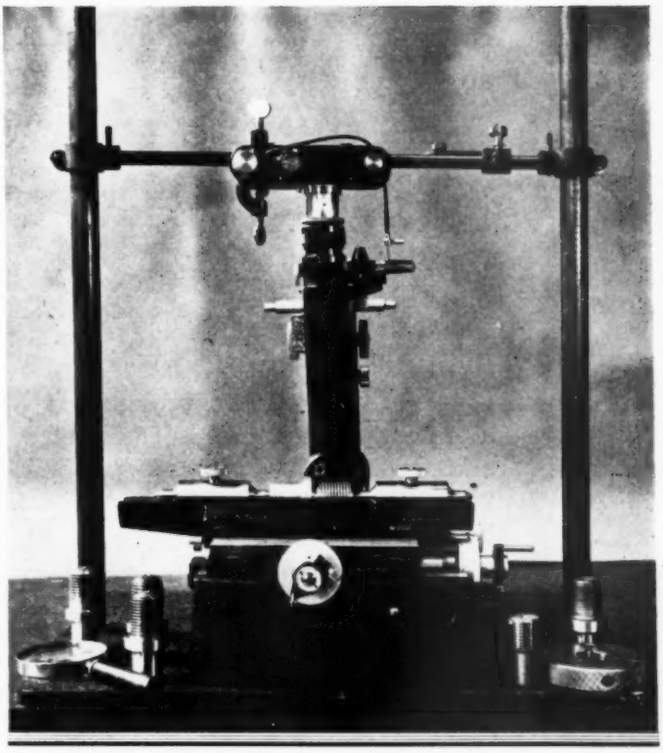

Figure 1. Toolmakers' microscope used for micrometric examination of sucker rod threads.

The pitch diameters of all boxes and couplings far exceeded the newly revised maximum limit of 1.001 inch; the smallest being 0.0083 inch and the largest 0.0203 inch greater than this value. It has been noted above that any experimental errors in this determination would give low rather than high values for pitch diameters. In general, lead errors were much less than those found in the pins, while angle errors were slightly greater.

Figures 7 to 10 inclusive are representative of the thread forms of the boxes and couplings.

Significance of the Results

The series of thread studies which by necessity has been only briefly detailed brought out numerous points that merit serious consideration by all manufacturers and users of sucker rods. Of first importance is the fact that the A. P. I. specifications are not being adhered to. Either the specifications are too rigid and exacting or the manufacturers are unaware of the properties of their own products. It is readily apparent that the latter supposition is the most charitable view possible under the existing circumstances. Furthermore, the conclusion seems to be warranted that neither manufacturers nor users have made it a general practice to inspect the products with A. P. I. type gages. In view of the improvement which one manufacturer was able to make in his product when acquainted with the facts, it appears probable that the revised specifications are not so rigid as to impose undue hardships on the manufacturers. At the same time it is evident that if the pins are to be kept within the specified limits they must be machined in the most rigid and improved type of threading machines equipped with an accurate and positive lead control and the highest grade of ground thread chasers. The same is true to a slightly less extent for boxes and couplings. It can also be concluded without question that pins cannot be consistently made to the present A. P. I. specifications by any

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method which involves heat treating operations after threading.

On page 2 of the Supplement to the Fourth Edition of the Sucker Rod Specifications is the following addition to paragraph 3: "Any manufacturer authorized to use the A. P. I. monogram on his products shall forfeit this right if the monogram is not used on material manufactured or sold in accordance with these specifications, within a period of twelve (12) months after such authority has been granted." It is now incumbent upon the Committee to determine whether the present specifications afford sufficient latitude for regular production operations and, if it is so decided, to take the same uncompromising stand relative to the use of the A. P. I. monogram by manufacturers whose products do not consistently meet the requirements. There is much to recommend a periodical check of the products of manufacturers authorized to use the A. P. I. monogram by some agency duly appointed for the purpose. Systematized gaging of representative samples from each order received by purchasers would also aid in rectifying the present situation.

Since errors in lead are very largely responsible for the immediate difficulties, it is suggested that a lead tolerance not exceeding 0.001 inch would insure sucker rod joints of improved quality and performance. Joints in which the entire pitch diameter tolerances are used up in lead and angle errors are more prone to premature failure because of the reduced areas of contacts in the threads.

There is a real menace to the standardization program in the conditions which have been shown to exist since the production costs of those manufacturers exerting added efforts to meet the specifications are greater than those of the manufacturers not greatly concerned with the accuracy of their threading operations and if no penalty is attached to lax methods of fabrication conditions will eventually revert to their former state of general dissatisfaction.

Acknowledgment

The authors wish to acknowledge the co-operation of Mr. E. W. Voss, of the George Scherr Co., in providing the Zeiss thread measuring microscope used in this investigation.

Author's Note

Sucker rod manufacturers desiring data on their own products included in this study will be supplied upon request.

TABLE 1.

Effect of Errors in Lead and Thread Angles on Pitch Diameter Tolerances for 10 Pitch Threads of the American National Coarse Thread Series.

Fit	Pitch Diameter Tolerance	Lead Errors Consuming One-Half of Pitch Diameter Tolerance	Errors in Half-Angle Consuming One-Half of Pitch Diameter Tolerance
Class 3	0.0045 in.	0.0013 in.	0° 52′
Class 4	0.0023 in.	0.0007 in.	0° 26′

TABLE 2.

Summary of Tests Made with A. P. I. Working Gages on Representative Samples of the Principal Makes of Sucker Rods[1].

Make	Date of Manufacture	Pitch Diameter[2] (in.) End of Pin	Pitch Diameter[2] (in.) Center of Pin	Pitch Diameter[2] (in.) Last Full Thread	Plug and Ring Gage Results: Box or Coupling[3] "Go" Plug	Box or Coupling[3] "No Go" Plug	Pin "Go" Ring	Pin "No Go" Ring	Remarks
A[7]	5-30	0.9950	0.9965	0.9965	2 turns	passed	0.75 in. standoff	passed	B&P
A	5-30	.....	.....	.....	2 turns	passed	0.63 in. standoff	2 turns	B&P
A	5-30	0.9950	0.9950	0.9950	2 turns	passed	0.63 in. standoff	passed	B&P
A	5-30	0.9950	0.9955	0.9955	1½ turns	passed	0.63 in. standoff	passed	B&P
A[4,7]	1-31	0.9952	0.9955	0.9963	.....	.....	0.22 in. standoff	¼ turn	B&P
A[4]	1-31	0.9938	0.9952	0.9960	.....	.....	0.23 in. standoff	¼ turn	B&P
A[4]	1-31	0.9948	0.9953	0.9958	.....	.....	0.25 in. standoff	½ turn	B&P
B[7]	.....	0.9950	0.9970	0.9970	passed	all in	0.41 in. standoff	2½ turns	B&P
B	.....	0.9940	0.9955	0.9955	passed	all in	0.25 in. standoff	2½ turns	B&P
B	.....	0.9950	0.9955	0.9965	passed	all in	0.38 in. standoff	2¼ turns	B&P
B[4]	.....	0.9942	0.9955	0.9955	.....	.....	0.84 in. standoff	¼ turn	B&P
B[4]	.....	0.9938	0.9946	0.9946	.....	.....	passed	¼ turn	B&P
B[4]	.....	0.9932	0.9945	0.9950	.....	.....	passed	¼ turn	B&P
C[7]	11-29	0.9915	0.9955	0.9975	½ turn	no turns	0.56 in. standoff	3½ turns	B&P
C	11-29	0.9925	0.9960	0.9960	¼ turn	no turns	0.50 in. standoff	5¼ turns	B&P
C	11-29	0.9925	0.9960	0.9980	½ turn	no turns	0.63 in. standoff	3¾ turns	B&P
D	.....	0.9900	0.9940	0.9960	.....	.....	passed	5½ turns	DP[5]
	.....	0.9900	0.9930	0.9950	.....	.....	0.22 in. standoff	4¾ turns	DP[6]
D	.....	0.9900	0.9930	0.9950	.....	.....	passed	6 turns	DP[5]
	.....	0.9900	0.9940	0.9950	.....	.....	0.80 in. standoff	4½ turns	DP[6]
D[7]	.....	0.9895	0.9935	0.9955	.....	.....	passed	5½ turns	DP[5]
	.....	0.9895	0.9940	0.9960	.....	.....	0.22 in. standoff	4¼ turns	DP[6]
E	4-30	0.9930	0.9980	0.9990	passed	all in	0.81 in. standoff	1 turn	DP[5]
	4-30	0.9940	0.9980	0.9990	passed	all in	0.81 in. standoff	¾ turn	DP[6]
E	4-30	0.9950	0.9980	0.9990	passed	all in	0.81 in. standoff	1 turn	DP[6]
	4-30	0.9920	0.9970	0.9980	passed	all in	0.75 in. standoff	1¼ turns	DP[5]
E[7]	4-30	0.9935	0.9980	0.9993	passed	all in	0.88 in. standoff	1½ turns	DP[6]
	4-30	0.9900	0.9970	0.9970	passed	all in	0.81 in. standoff	1¼ turns	DP[5]
E	4-30	0.9930	0.9990	0.9990	passed	all in	0.81 in. standoff	1 turn	DP[6]
	4-30	0.9935	0.9985	0.9990	passed	all in	0.84 in. standoff	½ turn	DP[5]
F	.....	0.9950	0.9955	0.9955	passed	all in	0.28 in. standoff	1½ turns	B&P
F	.....	0.9965	0.9970	0.9970	passed	all in	0.81 in. standoff	1 turn	B&P
F	.....	0.9955	0.9970	0.9970	passed	all in	0.81 in. standoff	1 turn	B&P
F[7]	9-30	0.9930	0.9970	0.9980	passed	all in	0.75 in. standoff	2 turns	DP[6]
	9-30	0.9930	0.9960	0.9980	passed	all in	0.75 in. standoff	1¼ turns	DP[5]
F	9-30	0.9935	0.9955	0.9970	passed	all in	0.75 in. standoff	1½ turns	DP[6]
	9-30	0.9935	0.9960	0.9960	passed	all in	0.75 in. standoff	1½ turns	DP[5]
F	9-30	0.9935	0.9950	0.9955	passed	all in	0.75 in. standoff	1½ turns	DP[5]
	9-30	0.9930	0.9940	0.9945	passed	all in	0.69 in. standoff	2 turns	DP[6]

[1] All ¾ in. rods.
[2] Measured with screw thread micrometer.
[3] Both ends of coupling.
[4] Retest samples selected from manufacturer's warehouse.
[5] Field end.
[6] Mill end.
[7] Selected for microscope examination.

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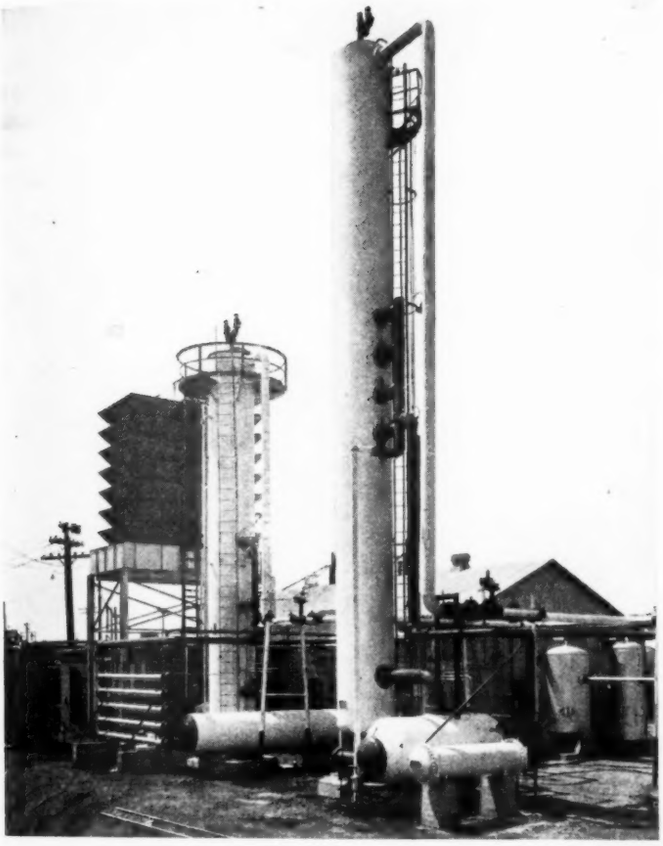

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Table 3.
SUCKER ROD PIN THREAD DIMENSIONS

Laboratory No. 913
Make—A
Type—Box and Pin
Date of Manufacture—1/31
Source of Sample—Submitted by Manufacturer

Date—2/17/31
Size—¾ in.
A. P. I. Monogram—Yes
Manufacturer's Code Mark—None

	Length of Pin "GP" (inches)	Length Imperfect Threads "eP" (inches)	Length Perfect Threads "EP" (inches)	Pin Cone Base to Face "J" (inches)	Pin Cone Base Diameter "kP" (inches)	Last Tool Mark to Face (inches)	Vanish Angle (Average Degrees)	Chamfer Angle (Tip of Pin)
A. P. I. Specification	1.3750	0.40	0.891	0.156	1.068	.....	9°0′	.....
Positive Tolerance	0.0610	.....	0.061	.....	0.000	.....	.....	.....
Negative Tolerance	0.0000	.....	0.000	.....	0.008	.....	.....	.....
Product	1.3800	0.34	0.930	0.125	1.054	0.73	9°9′	29°40′

Thread No. (Pin to Shoulder)	Pitch Diameter "CP" (inches)	Lead per Thread (inches)	Major Diameter "DP" (inches)	Minor Diameter "dP" (inches)	Thread Height "h" (inches)	Thread Width Crest (inches)	Thread Width Root (inches)	Thread Angles Right	Thread Angles Left	Total Error
A. P. I. Specification	0.9970	0.10000	1.06195	0.93927	0.06134	.....	.....	30° 0′	30° 0′	0° 0′
Positive Tolerance	0.0000	.....	0.0000	0.0000	.....	.....	.....	.....	.....	.....
Negative Tolerance	0.0020	.....	0.0128	0.0092	.....	.....	.....	.....	.....	.....
1	0.9958	0.10022	1.0568	0.9309	0.0604	0.0157	0.0859	30°26′	30° 5′	+0°31′
2	0.9953	0.09988	1.0576	0.9309	0.0607	0.0181	0.0862	30° 4′	30°12′	+0°16′
3	0.9947	0.10002	1.0549	0.9308	0.0611	0.0194	0.0857	29°57′	30°21′	+0°18′
4	0.9949	0.10002	1.0548	0.9308	0.0605	0.0170	0.0862	30° 0′	30° 3′	+0° 3′
5	0.9958	0.10004	1.0550	0.9317	0.0603	0.0164	0.0862	30°23′	30°27′	+0°50′
6	0.9965	0.10005	1.0551	0.9324	0.0601	0.0169	0.0861	30°14′	30°10′	+0°24′
Maximum	0.9965	0.10022	1.0576	0.9324	0.0611	0.0194	0.0862	30°26′	30°27′	+0°50′
Minimum	0.9947	0.09988	1.0548	0.9308	0.0601	0.0157	0.0857	29°57′	30° 3′	+0° 3′
Average	0.9955	0.10004	1.0557	0.9314	0.0605	0.0173	0.0861	30°11′	30°13′	+0°24′

Total lead error in perfect threads is —0.00023 in. Lead error in ½ in.—0.00017 in.

Table 4.
SUCKER ROD PIN THREAD DIMENSIONS[1]

MAKE	A[2]	B[2]	C[2]	D[2]	E[3]	F[3]	A[3]	A. P. I. Specifications
Type	B. & P.	B. & P.	B. & P.	D. P.	D. P.	D. P.	B. & P.	
Date of Manufacture	5-30	.....	11-29	11-29	4-30	9-30	1-31	
A. P. I. Monogram	Yes	No	Yes	Yes	Yes	Yes	Yes	
Code Mark	No	No	No	M	No	UB	No	
Length of Pin "GP" (in.)	1.3700	1.4500	1.5400	1.3550	1.4550	1.4100	1.3800	1.3750 (+.0610, —.0000)
Length Imperfect Threads "eP" (in.)	0.33	0.46	0.45	0.37	0.39	0.49	0.34	0.40
Length Perfect Threads "EP" (in.)	0.824	0.878	0.969	0.820	0.886	0.754	0.930	0.819 (+.061, —.000)
Pin Cone Base to Face "J" (in.)	0.221	0.107	0.119	0.161	0.181	0.170	0.125	0.156
Pin Cone Base Diameter "kP" (in.)	1.063	1.050	1.064	1.042	1.057	1.050	1.054	1.068 (+.000, —.008)
Last Tool Mark to Face (in.)	0.067	0.022	0.064	0.060	0.077	0.107	0.073	
Major Diameter "DP" (in.)	1.0579	1.0537	1.0552	1.0460	1.0540	1.0558	1.0557	1.06195 (+.0000, —.0128)
Minor Diameter "dP" (in.)	0.9323	0.9262	0.9134	0.9289	0.9228	0.9264	0.9314	0.93927 (+.0000, —.0092)
Pitch Diameter "CP" (in.)[4]	0.9953	0.9909	0.9875	0.9885	0.9901	0.9929	0.9955	0.9970 (+.0000, —.0020)
Pitch Diameter "CP" (in.)[5]	0.9960	0.9963	0.9941	0.9932	0.9947	0.9960	0.9957	0.9970 (+.0000, —.0020)
Pitch Diameter Taper (in.)	0.0015	0.0020	0.0060	0.0065	0.0070	0.0050	0.0008	
Thread Height "h" (in.)	0.0627	0.0651	0.0706	0.0584	0.0661	0.0637	0.0605	0.06134
Thread Width at Crest (in.)	0.0115	0.0123	0.0131	0.0171	0.0123	0.0124	0.0173	
Thread Width at Root (in.)	0.0856	0.0796	0.0908	0.0962	0.0918	0.0885	0.0861	
Lead per Thread (in.)	0.10037	0.09968	0.10101	0.10030	0.10037	0.10142	0.10004	
Total Lead Error (in.)	0.00219	0.00189	0.00604	0.00180	0.00223	0.00852	0.00023	
Vanish Angle (Average Degrees)	10°42′	8°58′	9°23′	8°43′	11°18′	8°58′	9° 9′	9°
Chamfer Angle (Tip of Pin)	10°34′	8°20′	.....	30°55′	21° 8′	26°50′	29°40′	
Thread Angle (Right)	31°52′	29°11′	29° 1′	30°18′	32° 5′	30° 3′	30°11′	
Thread Angle (Left)	29°39′	28°24′	28°29′	29°26′	29°34′	30° 5′	30°13′	
Total Thread Angle Error	+1°31′	—2°22′	—2°51′	+0° 4′	+1°43′	—0° 2′	+0°24′	

[1] ¾ in. sucker rods, averages of 6 perfect threads.
[2] Selected from stock.
[3] Submitted for test.
[4] Microscope measurement.
[5] Thread micrometer measurement.

Table 5.
SUCKER ROD BOX THREAD DIMENSIONS

Laboratory No. 686
Make—B
Type—Box and Pin
Date of Manufacture—
Source of Sample—Selected at Manufacturer's Plant

Date—2/20/31
Size—¾ in.
A. P. I. Monogram—No
Manufacturer's Code Mark—None

	Depth of Box "GB" (inches)	Length Imperfect Threads "eB" (inches)	Length Perfect Threads "EB" (inches)	Depth inc. Counterbore "GW" (inches)	Length of Threads "GY" (inches)	Depth of Counterbore "GZ" (inches)	Diameter of Counterbore "KB" (inches)	Pin Cone Base Diameter "kB" (inches)	Vanish Angle (Average Degrees)
A. P. I. Specification	1.875	0.20	1.04	1.54	1.24	0.30	1.080	1.068	9° 0′
Positive Tolerance	.....	.....	0.06	.....	.....	0.00	0.010	0.008	.....
Negative Tolerance	.....	.....	0.00	.....	.....	0.10	0.000	0.000	.....
Product	1.889	0.23	1.14	1.63	1.36	0.27	1.091	1.083	8° 7′

Thread No. (From Shoulder)	Pitch Diameter "CB" (inches)	Lead per Thread (inches)	Major Diameter "DB" (inches)	Minor Diameter "dB" (inches)	Thread Height "h" (inches)	Thread Width Crest (inches)	Thread Width Root (inches)	Thread Angles Right	Thread Angles Left	Total Error
A. P. I. Specification	0.9980	0.10000	1.06295	0.95470	0.05413	.....	.....	30° 0′	30° 0′	+0° 0′
Positive Tolerance	0.0020	.....	0.0164	0.0108	.....	.....	.....	.....	.....	.....
Negative Tolerance	0.0000	.....	0.0000	0.0000	.....	.....	.....	.....	.....	.....
1	1.0204	0.10041	1.0797	0.9601	0.0640	0.0167	0.0950	30°24′	30°15′	+0°39′
2	1.0206	0.10058	1.0807	0.9538	0.0661	0.0158	0.0954	30°53′	30°14′	+1° 7′
3	1.0197	0.10060	1.0811	0.9565	0.0657	0.0167	0.0960	31°12′	30°33′	+1°45′
4	1.0211	0.10039	1.0827	0.9559	0.0678	0.0143	0.0945	30°29′	29°46′	+0°15′
5	1.0197	0.10052	1.0817	0.9532	0.0660	0.0130	0.0965	31° 8′	31° 8′	+2°16′
6	1.0205	0.10000	1.0798	0.9540	0.0656	0.0163	0.0971	31° 3′	30° 9′	+1°12′
Maximum	1.0211	0.10060	1.0827	0.9601	0.0678	0.0167	0.0971	31°12′	31° 8′	+2°16′
Minimum	1.0197	0.10000	1.0797	0.9532	0.0640	0.0130	0.0945	30°24′	29°46′	+0°15′
Average	1.0203	0.10042	1.0810	0.9556	0.0659	0.0155	0.0958	30°51′	30°21′	+1°12′

Total lead error in perfect threads, —0.00250 in. Lead error in ½ in., —0.00250 in.

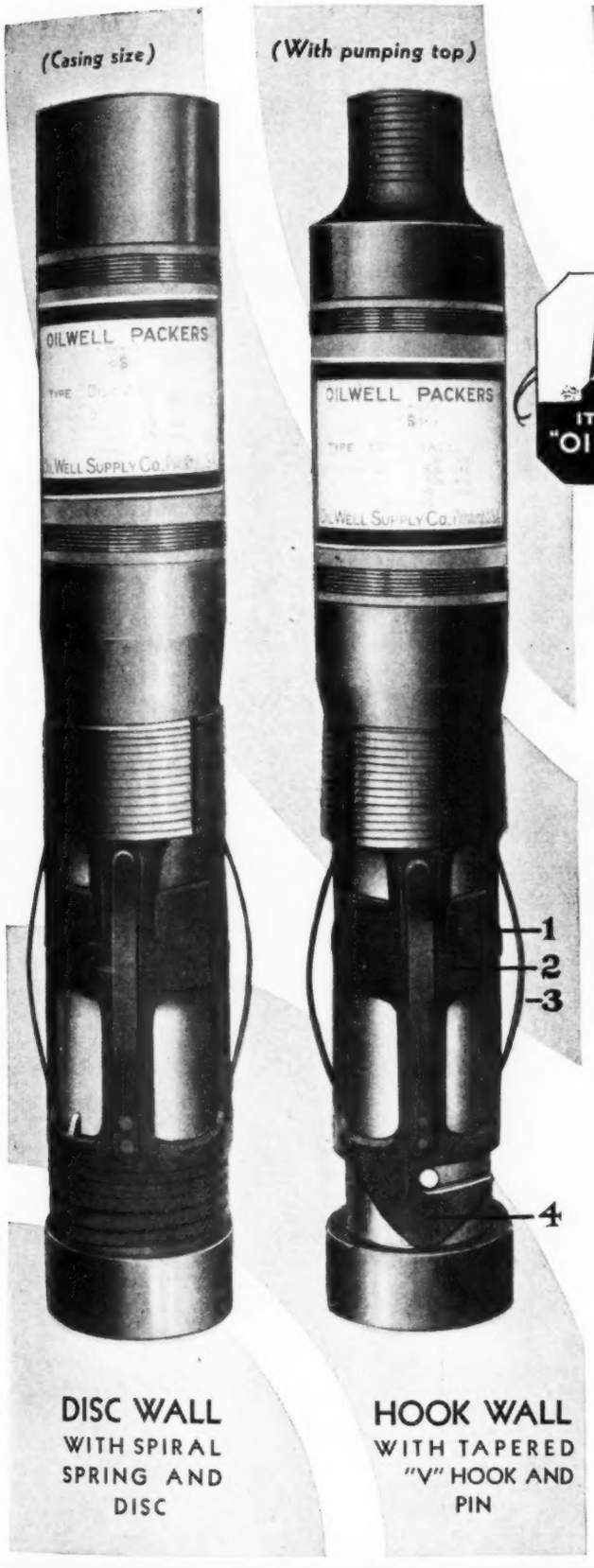

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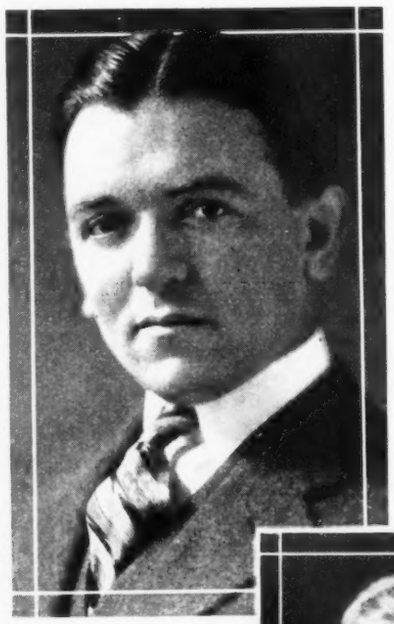
Table 6.
SUCKER ROD BOX THREAD DIMENSIONS[1]

MAKE	A[2]	B[2]	C[2]	D[2]	E[2]	F[3]	A. P. I. SPECIFICATIONS	
Type	B. & P.	B. & P.	B. & P.	D. P.	D. P.	D. P.		
Date of Manufacture	5-30	.....	11-29	11-29	4-30	9-30		
A. P. I. Monogram	Yes	No	Yes	Yes	Yes	Yes		
Code Mark	No	No	No	M	No	UB		
Depth of Box "GB" (in.)	2.080	1.889	1.980	.....	.....	.....	1.875	
Length Imperfect Threads "eB" (in.)	0.21	0.23	0.18	0.20	0.24	.....	0.20	
Length Perfect Threads "EB" (in.)	1.04	1.14	1.31	.....	1.02	.....	1.04	(+.06, —.00)
Depth Including Counterbore "GW" (in.)	1.52	1.63	1.68	.....	1.50	.....	1.54	
Length of Threads "GY" (in.)	1.24	1.36	1.40	.....	1.26	.....	1.24	
Depth of Counterbore "GZ" (in.)	0.28	0.27	0.28	0.30	0.24	0.26	0.30	(+.00, —.10)
Diameter of Counterbore "KB" (in.)	1.090	1.091	1.090	1.093	1.089	1.090	1.080	(+.010, —.000)
Box Cone Base Diameter "kB" (in.)	1.083	1.083	1.081	1.091	1.082	1.085	1.068	(+.008, —.000)
Major Diameter "DB" (in.)	1.0701	1.0810	1.0676	1.0668	1.0754	1.0692	1.06295	(+.0164, —.0000)
Minor Diameter "dB" (in.)	0.9611	0.9556	0.9636	0.9484	0.9526	0.9582	0.95470	(+.0108, —.0000)
Pitch Diameter "CB" (in.)	1.0170	1.0203	1.0156	1.0083	1.0105	1.0145	0.9980	(+.0020, —.0000)
Pitch Diameter Taper (in.)	0.0002	0.0001	0.0016	0.0017	0.0019	0.0005		
Thread Height "h" (in.)	0.0531	0.0659	0.0521	0.0587	0.0643	0.0551	0.05413	
Thread Width at Crest (in.)	0.0300	0.0155	0.0287	0.0202	0.0176	0.0240		
Thread Width at Root (in.)	0.0933	0.0958	0.0948	0.0901	0.0927	0.0914		
Lead per Thread (in.)	0.10028	0.10042	0.10025	0.09987	0.09999	0.10017		
Total Lead Error (in.)	0.00167	0.00250	0.00149	0.00078	0.00009	0.00100		
Vanish Angle (Average Degrees)	7° 13′	8° 7′	10° 15′	6° 15′	11° 34′	8° 12′	9°	
Thread Angle (Right)	32° 12′	30° 51′	31° 51′	30° 13′	29° 50′	31° 6′		
Thread Angle (Left)	28° 13′	30° 21′	31° 30′	30° 52′	29° 55′	31° 27′		
Total Thread Angle Error	+0° 36′	+1° 12′	+3° 21′	+1° 11′	—0° 17′	+2° 32′		

[1] ¾-inch sucker rods, averages of 6 perfect threads.
[2] Selected from stock.
[3] Submitted for test.

Much Interest Shown in Gasoline Convention

Right—Dr. E. R. Lederer, Texas Pacific Coal & Oil Co., President, Natural Gasoline Assn. of America. Below — R. E. Beckley, Standard Gasoline Co. of California, Vice-President, Natural Gasoline Assn. of America.



Left—Emby Kaye, Skelly Oil Co., Vice-President, Natural Gasoline Assn. of America. Below — Ray E. Miller, Secy.-Treas. Natural Gasoline Assn. of America.

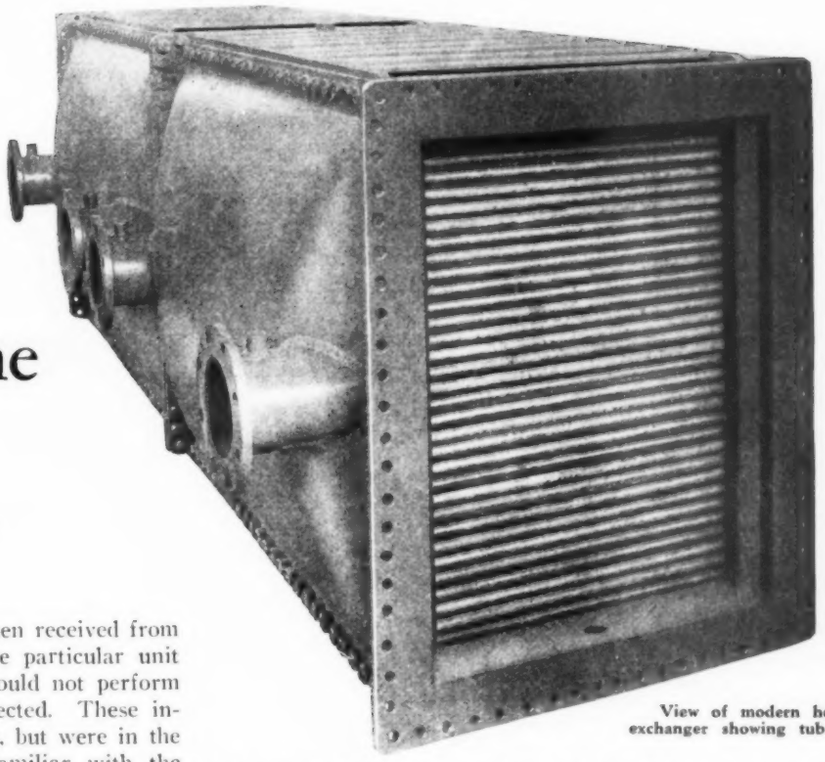
A LARGE attendance is expected for the tenth annual convention of the Natural Gasoline Association of America which will be held May 19-21 at the Mayo Hotel, Tulsa.

In addition to attending to the regular business of the annual meeting a number of papers on timely subjects will be read by prominent men of the natural gasoline division of the industry. These papers will be discussed following their presentation.

The problems of natural gasoline manufacture in the Mid-Continent region and the California fields will be brought out in the presentation of much information both of a technical and non-technical nature.

Heat Exchange *in the* Natural Gasoline Plant

By L. J. COULTHURST[1] *and* L. P. SCOVILLE[2]



View of modern heat exchanger showing tubes.

IN the past year many inquiries have been received from plant superintendents concerning some particular unit of heat exchange equipment which would not perform the heat transfer duty that had been expected. These inquiries were not in the form of complaints, but were in the nature of an attempt to become more familiar with the equipment. In a majority of cases it was found that the supposed heat exchange inefficiency was a natural reaction caused by one or more of the nine variables appreciably controlling heat interchange.

It is evident that the same heat exchanger will perform differently in various types of service. Too often in the past there has been an inclination to let it rest on that generality.

In the design of heat exchange equipment a study of the factors involved is absolutely essential. Even at the present time, with exceptions, an over-all factor of heat transfer is all that is considered, with no thought of the various resistances to heat flow offered by the two fluids and the tube wall between them. In determining the efficiency of an exchanger, this over-all coefficient indicates a great deal, but in considering why one exchanger gives a lower coefficient than another, it is of little value. For example, in the common tube and shell type of exchanger with a given fluid velocity in the shell (V_1) and a velocity in the tubes (V_2), an over-all heat transfer, K (B. t. u./sq. ft./deg. M. T. D./hr.), is found. In order to increase the heat transfer, would increasing V_1 or V_2 be of greater benefit? With a knowledge of the transfer coefficient on each side of the tubes and their change with velocity, this can be ascertained easily. Often it is found that an increase in the velocity on one side will have only a slight effect upon the heat transferred, while a change in the velocity on the other side is very effective.

The problem of heat transfer from liquids through tubes therefore devolves into a study of the coefficients between the liquid and the tube itself, disregarding (except for the temperature gradient) the heating or cooling medium which is on the other side of the tube.

It was once thought that if a metal tube with a heat conductivity four times greater than that of another tube were used, the heat transfer value would be proportionately increased. When a check was made of this possibility it was found to be in error and that the fluids themselves set up certain definite resistances. Since that time it has been generally accepted that when a fluid is flowing along the surface of a solid, there is a relatively stationary film of fluid adhering to the surface of the solid. Through such a film, heat can be transmitted by conduction only. Because most liquids are very poor conductors of heat, a large heat flow resistance is to be expected through this film.

The thickness of the fluid film is dependent upon several factors. It is probable that as the turbulence increases the film becomes thinner. Thus, it follows that the thickness of the film should increase directly as a function of the viscosity of the fluid, and inversely as functions of the velocity, density and tube diameter. It can be anticipated that the shorter the length of straight tube, the greater will be the turbulence and consequently a resultant thinner film. From this surmise it would be expected that a short tube would give a better transfer rate than a longer one. This has been found to be true, at least in the case of cross-flow type of heat exchanger as designed by Southwestern. For example, a 24-inch tube length, water to water, heat interchanger was actually found to be 11 per cent more efficient than one of 36 inches in length.

A graphic representation of the temperature gradients through the fluid films and the tube wall in an oil cooler is shown in Fig. 1, wherein:

T_1—Average water temperature.

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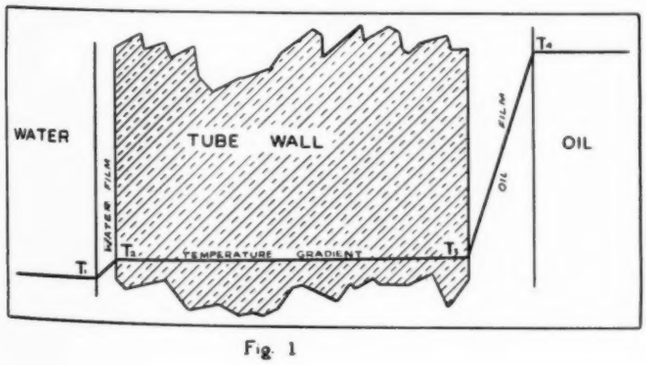

Fig. 1

T_2—Average temperature of inside surface of tube wall.
T_3—Average temperature of outside surface of tube wall.
T_4—Average temperature of oil.

Due to the relatively low viscosity of the water, its film is represented as thinner than that of the oil. The temperature gradient through the water film is less than that through the oil, due to the fact that the heat conductivity of water is about 0.35 B. t. u./sq. ft./ft. thickness/deg. M. T. D./hr., while that of the oil can be taken as 0.08. Since the conductivity of the metal in the tube wall is from 25 to 250 (depending upon the metal or alloy used), the temperature gradient through this wall is small.

It can be seen that in this particular case the temperature gradient is shown as larger through the oil film and, since this film is also thicker, the resistance to heat flow is far greater than through either the tube wall or water film. Therefore, within certain limits, it may be said that the oil film is the controlling factor in an oil to water cooler and that an increase in the oil velocity would give a large change in the heat transfer rate, while a change in the water velocity would have small effect. It can also be seen that the kind of metal in the tubes would make little difference in this type of service from a heat transfer standpoint. However, in the case of a water to water exchanger, where the velocities are of the order of two feet per second or greater, the type of metal or alloy from which the tubes are made becomes a considerable factor.

The transfer of heat is dependent upon a series of resistances, namely:

1. Resistance of the film on the inside of the tubes.
2. Resistance of the tube wall.
3. Resistance due to scale on both sides of the tube wall.
4. Resistance of the film on the outside of the tubes.

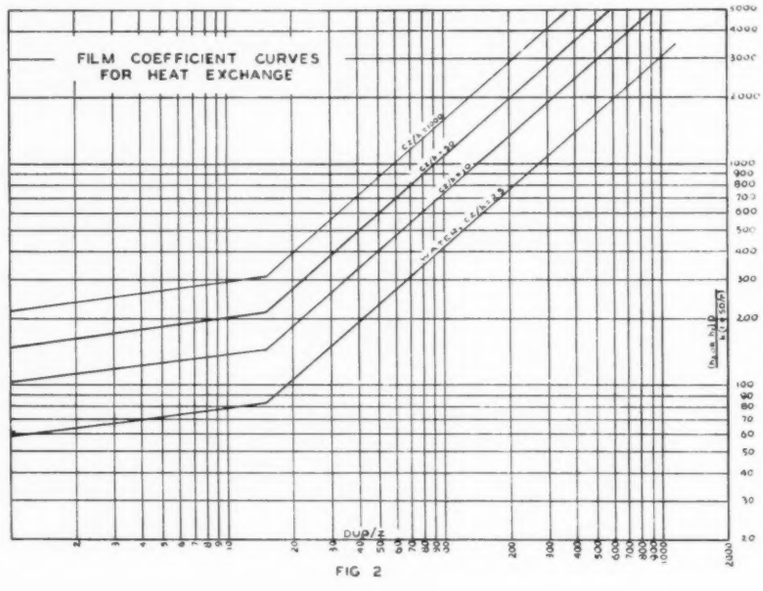

FIG 2

Consequently, to predict the performance of heat exchangers, use is made of these resistances and in so doing one calculates what is termed as "film coefficients."

In this article the nomenclature used is as follows:

c—Specific heat of film.
D—Actual inside diameter of tubes, or equivalent in shell, in inches.
h_T—Film heat transfer coefficient inside tubes in B. t. u./sq. ft./deg. M. T. D./hr.
h_S—Film heat transfer coefficient outside tubes, e. g., on shell side, in B. t. u./sq. ft./deg. M. T. D./hr.
K—Over-all heat transfer coefficient in B. t. u./sq. ft./deg. M. T. D./hr.
k_F—Thermal conductivity of stationary fluid film in B. t. u./ft. thickness/sq. ft./deg. M. T. D./hr.
k_T—Thermal conductivity of tubes in B. t. u./ft. thickness/sq. ft./deg. M. T. D./hr.
M. F. T.—Mean film temperature.
M. T. D.—Logarithmic mean temperature difference.
r—Ratio of straight pipe to inside diameter (or equivalent empirical value for shell).
U—Velocity of body of fluid in ft./sec.
Z—Viscosity of fluid film in centipoises absolute.*
e—Density of fluid in lbs./cu. ft.

The familiar resistance formula is

$$K = \frac{1}{\frac{1}{h_T \times \text{area}} + \frac{\text{wall thickness in ft.}}{k_T \times \text{area}} + \frac{1}{\text{scale coefficient} \times \text{area}} + \frac{1}{h_S \times \text{area}}}$$

For all practical purposes the ratios of the areas involved may be considered as unity, although in cases of tubes thicker than 18 gage it is well to use a ratio in conjunction with h_T of less than unity, and with h_S greater than unity.

For 18-gage tubes:

$$K = \frac{1}{\frac{1}{h_T} + \frac{\text{wall thickness in ft.}}{k_T} + \frac{1}{\text{scale coefficient}} + \frac{1}{h_S}}$$

Obviously where so many variables are concerned, it is unwieldy to consider them individually. It follows that plotting of selected groups of these variables is the logical way of handling them. In the book, "Principles of Chemical Engineering," Walker, Lewis and McAdams have as the ordinate $\frac{(h_S \text{ or } h_T)D}{k(1 + 50/r)}$ and the abscissa $\frac{DUe}{Z}$.

A modification of their curve is shown in Fig. 2. It is a system of $\frac{cZ}{k}$ curves represented to apply generally to several types of equipment and, of course, will not apply exactly to any particular commercial piece of heat exchange apparatus. It has been found by the Southwestern Research Department that the $\frac{cZ}{k}$ curves are spaced from each other by a gradually changing power. In this particular system (Fig. 2) it will be recognized that the power of $\frac{cZ}{k}$ up to the value 10, averages 0.50; from 10 to 50, 0.25; from 50 higher, 0.15.

Several practical problems will indicate the use of film coefficients. Consider an absorption oil cooler of the tube and shell type using water as the cooling medium. The exchanger tubes are one-inch standard wrought iron pipe

* To change Saybolt viscosity to centipoises absolute the following equation is used: $Z = d(0.220\,\Theta - \frac{180}{\Theta})$

where d = density of fluid at temperature of viscosity determination.
Θ = Time in Saybolt Universal seconds.

48 inches in length. The 37.5° A. P. I. absorption oil enters the shell side of the exchanger at 150° F. and is to be cooled to 70° F. The water enters the tubes at 65° F. and leaves at 90° F. The logarithmic mean temperature difference is 22.1° F. $[(150—90)—(70—65)]$. The oil

$$\frac{}{\dfrac{2.3 \log_{10} (150—90)}{(70—65)}}$$

velocity through the shell side is assumed to be 2.4 ft./sec. The water velocity through the tubes is 1.7 ft./sec.

The mean film temperature, M. F. T., should be determined. The resistance of the water film is estimated to be about 0.1 of the total resistance involved, so that the M. F. T. for the water will be its average fluid temperature plus one-half the resistance times the M. T. D.—

$$65 + \frac{90}{2} + 0.1 \times \frac{}{2}$$

M. T. D. = 78.6° F. Neglecting the resistance of the tube wall, that due to the oil film will be about 0.9 of the total. Then the M. F. T. of the oil will be $110 - \frac{0.9}{2} \times 22.1 = 100°$ F.

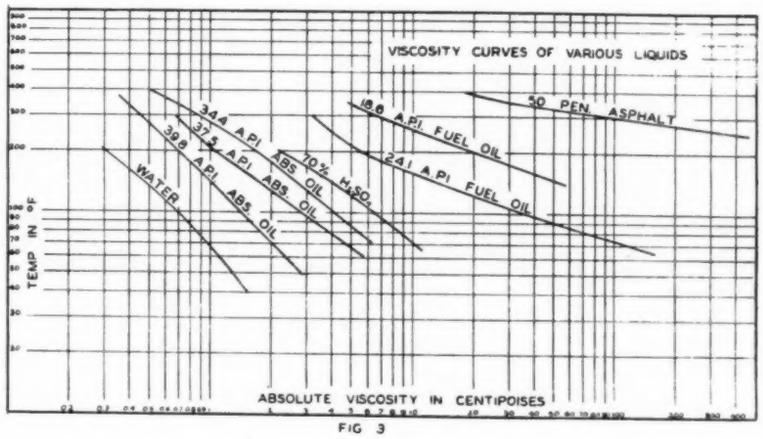

FIG 3

Consider the water film first. $\frac{DUe}{Z}$ must be evaluated. D, the inside diameter of the tubes (one-inch standard pipe), is 1.05 inches; U, the velocity of the water, is 1.7 ft./sec.; e, the density, is 62.3 lbs./cu. ft.; the viscosity, Z, of water at 78.6° F. is 0.88 centipoises (Fig. 3). Therefore:

$$\frac{DUe}{Z} = \frac{1.05 \times 1.7 \times 62.3}{0.88} = 126.5$$

The value of $\frac{cZ}{k}$ must also be determined. c, the specific heat, in the case of water may be considered as one for all practical purposes, since its value varies slightly with temperature. Z, as above, is 0.88; k is 0.35 B. t. u./sq. ft./deg. M. T. D./ft. thickness/hr. Therefore:

$$\frac{cZ}{k} = \frac{1.0 \times 0.88}{0.35} = 2.51$$ (in Fig. 2 an average $\frac{cZ}{k}$ value for water has been shown as 2.5).

From Fig. 2 it is found for the above values of $\frac{DUe}{Z}$ and $\frac{cZ}{k}$ that $\frac{h_T \times D}{k\,(1 + 50/r)}$ is 500. Since the length of tubes is 48 inches, $r = \frac{48}{1.05} = 45.7$.

$$\frac{h_T \times D}{k\,(1+50/r)} = \frac{h_T \times 1.05}{0.35\,(1 + 50/45.7)} = 143\ h_T = 500$$

Therefore, h_T, the film coefficient inside the tubes, = 350 B. t. u./sq. ft./deg. M. T. D./hr.

In order to obtain the film coefficient outside the tubes, hs, the same procedure is followed. The viscosity of 37.5° A. P. I. absorption oil at 100° F. is 2.8 centipoises. The functions D and r for the shell side of an exchanger of any particular make must be experimentally determined, therefore an assumption must be made in this case. Assume that D is 1.2 inches and r is 60.

$$\frac{DUe}{Z} = \frac{1.2 \times 2.4 \times 52.2}{2.8} = 53.7$$

The specific heat of 37.5° A. P. I. oil at 100° F. is 0.48 B. t. u./lb. (Fig. 4). The thermal conductivity, k, may be considered as 0.08 B. t. u./sq. ft./ft. thickness/deg. M.T.D./hr.

$$\frac{cZ}{k} = \frac{0.48 \times 2.8}{0.08} = 16.8$$

From Fig. 2—

$$\frac{hsD}{k\,(1 + 50/r)} = 490$$

$$\frac{hs \times 1.2}{0.08\,(1 + 50/60)}$$

Therefore, hs = 60.0.

One should now check the relative values of the resistances assumed in the determination of the values of the mean film temperature.

$$1/60 = 0.01667$$
$$1/350 = 0.00286$$

Total = 0.01953 (Disregarding the tube wall and scale.) The fraction due to the water film is $\frac{0.00286}{0.01953} = 0.146$. The fraction due to the oil film is $\frac{0.01667}{0.01953} = 0.853$. These check quite closely with the assumed values of 0.1 and 0.9, respectively. In cases where a large M. T. D. is involved and accurate design is necessary, care must be taken that the values assumed are fairly close to the ones used.

It is obvious that the conduction of heat through the water film will be equal to the film coefficient times the area, while that of the oil film will be the shell coefficient times the area outside the tubes. Since these areas are proportional to the internal and external diameters, respectively, ratios may be used in the resistance formula with the mean diameter for the tube itself as unity. If the tube is a standard one-inch pipe of wrought iron, the wall of the pipe itself has a conductivity of 40 B. t. u./ft. thickness/sq. ft./deg. M. T. D./hr. The thickness of the tube wall of one-inch pipe is 0.1325 inches, thus the conductivity through the tube wall is $\frac{40 \times 12}{0.133} = 3610$ B. t. u./sq. ft./deg. M. T. D./hr. The mean tube diameter is $\frac{1.315 + 1.05}{2} = 1.1825$ inches. Thus the area ratio to use for the water coefficient is $\frac{1.05}{1.1825} = 0.888$; that for the tube itself is $\frac{1.1825}{1.1825} = 1.000$;

that for the oil side is $\frac{1.315}{1.1825} = 1.112$. Therefore,

$$\text{Over-all } K = \frac{1}{\frac{1}{350 \times .888} + \frac{1}{3610 \times 1.000} + \frac{1}{60 \times 1.112}}$$

$= 54.1$ B. t. u./sq. ft./deg. M. T. D./hr.

This value assumes that the tubes are clean. If a further resistance of 1/2000 be added in for a scale formation, K is found to be 52.7.

It is exceedingly difficult to ascertain without a knowledge of the type of equipment, service, or length of time of operation just what value to insert for scale resistance. The resistance varies from 1/1300 for oil to oil heat exchange to a value of 1/1900 or less for water to water transfer with fairly clean tubes. It has been found in an absorption plant that the scale deposits more rapidly as the oil becomes cooler. Thus the scale factor is a larger amount in the gravity exchanger than in the preheater, still larger in the pressure exchanger, etc.

In order to illustrate how a difference in viscosity changes the transfer coefficient, consider that a 20° A. P. I. fuel oil is cooled in the previous exchanger with the same temperature and velocities involved.

The water film coefficient h_T is still 350. The viscosity of 20° A. P. I. fuel oil at 100° F. is 110 centipoises; e is 58.2 lbs./cu. ft.

$$\frac{DUe}{Z} = \frac{1.2 \times 2.4 \times 58.2}{110} = 1.525$$

The specific heat of this fuel oil at 100° F. is 0.44.

$$\frac{cZ}{k} = \frac{0.44 \times 110}{0.08} = 605$$

From Fig. 2, $\frac{h_s \times 1.20}{0.08\,(1 + 50/60)} = 210$

$h_s = 25.7$

$$\text{Over-all } K = \frac{1}{\frac{1}{350 \times .888} + \frac{1}{3610 \times 1.000} + \frac{1}{2000} + \frac{1}{25.7 \times 1.112}}$$

$K = 25.6$

Now go back to the conditions in the first case where absorption oil was being cooled. Instead of going into great detail as was done in the other calculations, a simpler method of estimation will be used in which accuracy is slightly sacrificed for speed. In all cases a value of 0.5 for the specific heat of oil and average temperatures rather than mean film temperatures will be employed. Further, use the same area for both the tube and shell side, and 1.0 for the viscosity of water.

The viscosity of the oil at the average of

$$\frac{150 + 70}{2} = 110° \text{ F.},$$

is 2.4 centipoises. Therefore, for the shell side of the exchanger:

$$\frac{DUe}{Z} = \frac{1.2 \times 2.4 \times 52.2}{2.4} = 62.7$$

$$\frac{cZ}{k} = \frac{0.5 \times 2.4}{0.08} = 15.0$$

$$\frac{h_s \times D}{k\,(1 + 50/r)} = 540 = \frac{h_s \times 1.20}{k\,(1 + 50/60)}$$

$h_s = 66$

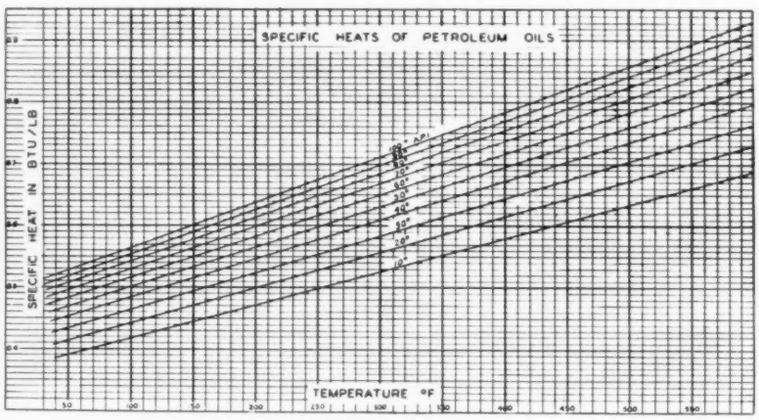

FIG. 4

For the tube side of the exchanger:

$$\frac{DUe}{Z} = \frac{1.05 \times 1.7 \times 62.3}{1.0} = 111.0$$

$$\frac{cZ}{k} = \frac{1.0 \times 1.0}{0.35} = 2.86$$

$$\frac{h_T \times D}{k\,(1 + 50/r)} = 490 = \frac{h_T \times 1.05}{0.35\,(1 + 50/47.5)}$$

$h_T = 345$

$$\text{Over-all } K = \frac{1}{\frac{1}{345} + \frac{1}{3610} + \frac{1}{2000} + \frac{1}{66}} = 53.0$$

This value is in excellent agreement with 52.7, which was previously evaluated in great detail. This method of evaluation is not recommended where a large M. T. D. is involved.

Very little work has been done on boiling or condensing films. A great deal of interest is centered upon this phase of heat transfer at the present time, however, and information as to these coefficients should be forthcoming.

Walker, Lewis and McAdams give a formula, $h_v = 2200KJ$, wherein:

h_v—Film coefficient for condensing fluid in Btu./sq. ft./deg. M. T. D./hr.

K—Thermal conductivity of fluid in B.t.u./sq. ft./ft. thickness/deg. M. T. D./hr.

J—Fluidity (reciprocal of viscosity in centipoises).

A conservative value of 1800 gives good results for steam condensation, although values of 4000 are not uncommon. There is an indication that the steam velocity is a considerable factor, possibly a variable dependent upon the degree to which it keeps the tube surface clean. The presence of non-condensable vapors seems to lower the transfer rate in condensing service.

The use of condensing films can be illustrated by considering a hypothetical preheater for absorption oil in the form of a one-inch standard pipe 25 feet long inserted in

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a two-inch standard pipe of the same length. Suppose that 120-pound gage steam flows through the one-inch pipe, the exchanger being installed vertically with the steam entering at the top and a trap at the bottom to quickly carry away the condensed water. Assume that 40 degrees A. P. I. absorption oil flows counter-currently to the steam on the outside of the one-inch pipe with a velocity of 2 feet per second. Further assume that the oil is to be heated from 270 degrees F. to 335 degrees F. The temperature of 120-pound gage steam is 350 degrees F., consequently the M. T. D. is 38.8 degrees. The steam coefficient of heat transfer, h_T, may be considered as 2000. With such a high coefficient on the steam side, it may be considered that all the resistance is on the oil side. The M. F. T. of the oil is then:

$$\frac{270 + 335}{2} + 38.8 \times 0.5 = 322 \text{ degrees F.}$$

The viscosity, Z, at 322 degrees F., is 0.43 centipoises; the specific heat, c, is 0.623.

In an annular space of this type a value of D is that diameter having the same hydraulic radius as the space involved. The hydraulic radius is the area, $[(2.067)^2 - (1.315)^2]\pi/4$, divided by the average wetted perimeter, $[2.067 + 1.315]\pi/2$.

Hydraulic radius = 0.376.

Therefore, D = 0.752.

A simpler method for determining D for cases such as this is to substract the two diameters. $(2.067 - 1.315) = 0.752$.

$$\frac{DUe}{Z} = \frac{0.752 \times 2.0 \times 0.825 \times 62.3}{0.43} = 180$$

$$\frac{cZ}{k} = \frac{0.623 \times 0.43}{0.08} = 3.33$$

From Fig. 2, $\dfrac{h_s \times D}{k\,(1 + 50/r)} = 750$

$$r = \frac{25 \times 12}{0.752} = 399$$

Therefore, $\dfrac{h_s \times 0.752}{0.08(1 + 50/399)} = 750$, and $h_s = 89.8$.

Less scale is usually deposited in a preheater than in a cooler, therefore the scale resistance will be considered as 1/2500.

The resistance of the tube wall is $\dfrac{0.133}{12 \times 40}$ = 1/3610.

$$\text{Over-all } K = \frac{1}{\frac{1}{2000 \times .888} + \frac{1}{3600} + \frac{1}{2500} + \frac{1}{89.8 \times 1.112}} = 89.5$$

No discussion of film coefficients is complete without cautioning against the practice of calculating the decrease in heat exchange coefficients due to a scale formation by a mere multiplication of the over-all coefficient by some factor. For example, assume that the film coefficient, h_T, for the fluid inside the tubes of a tube and shell exchanger is 210, while that on the shell side, h_s, is 1000, and the conductivity of the tube wall, k_T, is 4000.

$$\text{Over-all } K = \frac{1}{\frac{1}{210} + \frac{1}{4000} + \frac{1}{1000}} = 167$$

Consider that a scale has been deposited which has a conductivity of 1200. The over-all K will now be 146, or 87.4 per cent of the former value.

When this same exchanger operates under other conditions, h_T may change to 100 and h_s to 150. The over-all K will then be 59.1. However, after adding the same scale resistance as before, the over-all K is found to be 56.3, or now 95.2 per cent of the value with clean tubes instead of 87.4 per cent.

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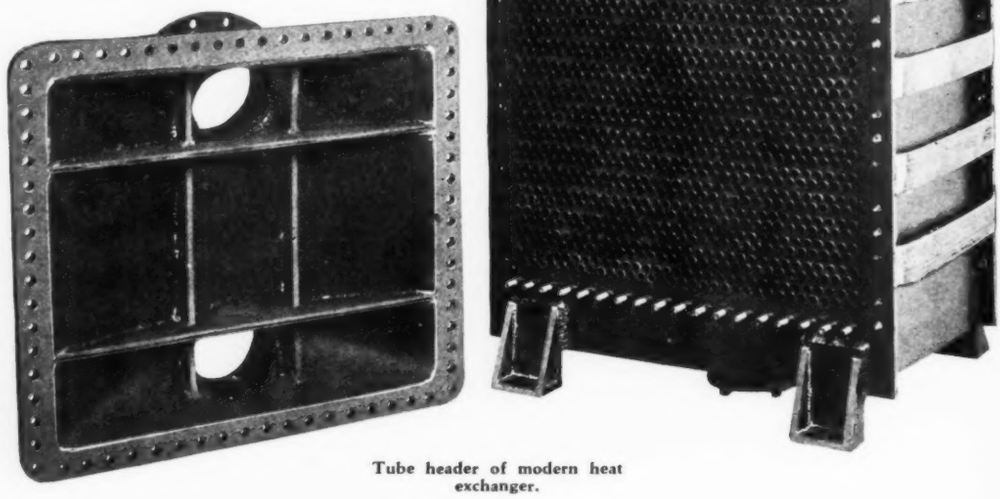

Tube header of modern heat exchanger.

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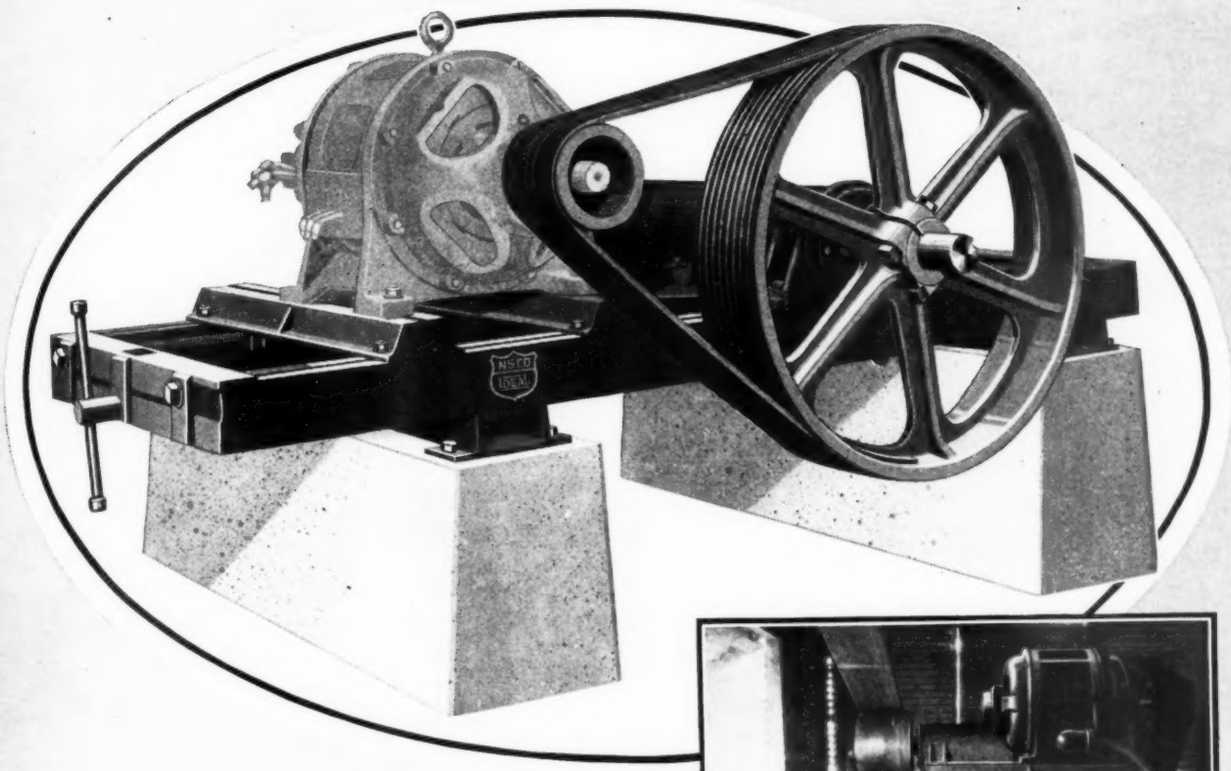

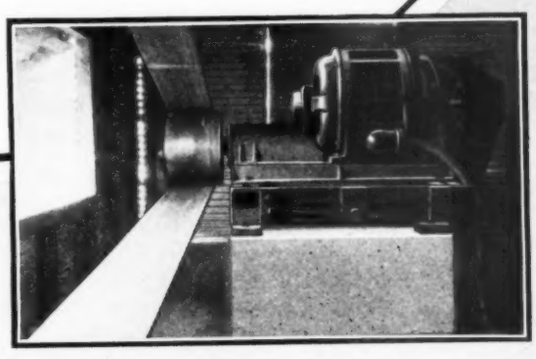

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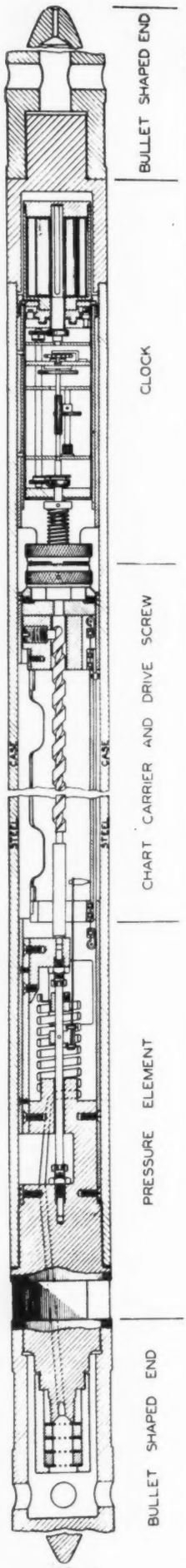

Fig. 1

Bottom Hole Pressures *in* Oil Wells*

By C. V. MILLIKAN[1] *and* CARROLL V. SIDWELL[2]

THERE is nothing more important in petroleum engineering than a definite knowledge of the pressure at the bottom of an oil well at any existing operating condition, and the relation of this pressure to the pressure within the producing formation. A knowledge of bottom-hole pressures is fundamental in determining the most efficient methods of recovery and the most efficient lifting procedure, yet there is less information about these pressures than about any other part of the general problem of producing oil.

Determination of Bottom-Hole Pressures

Bottom-hole pressure may be calculated or determined by several methods. On an inactive well it may be calculated from the fluid head or, if the well is shut in, by adding the casing-head pressure, the static head of the gas, and the fluid head. In wells flowing naturally through tubing the pressure at the bottom of the tubing may be calculated by adding the pressure at the casinghead between the tubing and the casing and the pressure due to the weight of the column of gas, but there is always possibility of error caused by fluid being in the annular space above the bottom of the tubing. If a well with tubing is flowing through either the annular space or the tubing, sufficient gas may be injected through the static space to insure that it is free of fluid but not sufficient to establish an appreciable friction loss. The pressure at the bottom of the tubing can then be calculated by adding to the pressure at the tubing head, the pressure due to the weight of the column of gas. This is probably the most accurate method of calculating bottom-hole pressures. In wells flowing by gas lift, the pressure at the point the gas enters the flow may be calculated by a gas flow formula.

Several types of pressure bombs have been used to measure the pressure at the bottom of wells. One is a piece of steel tubing with a check valve in the bottom and a connection for a pressure gauge at the top. It is lowered into the well to the point at which the pressure is desired then brought to the surface and the pressure read from a pressure gauge put on the top connection. Several bombs have been made which enclose a maximum reading pressure gauge. Some use a maximum indicating pointer, but this is not so satisfactory as a stylus on the pointer scratching a smoked surface. Consideration has been given to electrical instruments which, on being lowered into a well, give a continuous reading at the surface, but so far as is known this method has not yet been developed to practical use. A recording gauge built up with a common gauge pressure element, recording on a small circular clock-driven chart, has been used some, but its use is limited because of its large diameter

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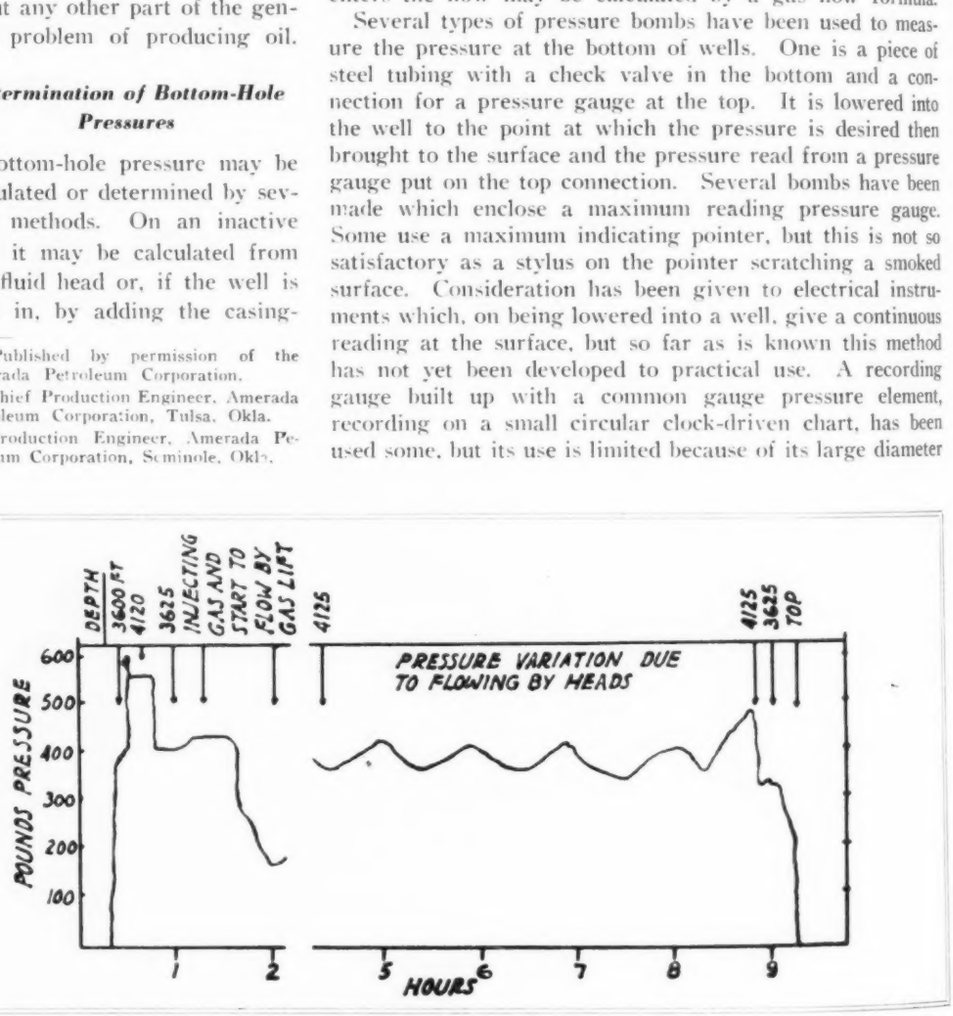

Fig. 2

and difficulty of close reading. Another recording gauge is being developed by which the pressure is determined with a piston and spring, on the same principle as a steam indicator gauge, and another obtains the pressure from a fluid filled tube with elastic walls.

The Amerada Pressure Gauge was used in determinating the bottom-hole pressures considered in this paper. It was developed in the laboratory of the Geophysical Research Corporation under the direction of Dr. F. M. Kannonstine. A cross-sectional drawing of the instrument is shown in Figure 1. The gauge consists of three main parts: Clock, chart carrier, and pressure element. The clock is of special design, having a diameter of 1⅜ in. and an over-all length of 7 in. The carrier holds a chart 7 in. long and 2⅞ in. wide. The movement of the chart is obtained by a central screw operated by the clock. This screw drives the chart carrier downward so that its weight almost balances the friction, thus reducing the power demand on the clock. The pressure element consists of pressure element tubing, fabricated into a spiral coil ⅞ in. in diameter and 7 in. long. The lower end of this tube is soldered to an opening in the base, which extends to the outside of the bomb. The upper end is sealed and attached to a shaft to which is also attached an arm and brass stylus for recording on a metallic-faced paper chart. The entire instrument is built on a frame which fits into a steel case, and as it is run into the well is 41 in. long, 2 in. outside diameter, and weighs 25 lbs. It is usually run on a steel wire measuring line.

Five different speed clocks have been made which will run the full length of a chart in one, three, twelve, twenty-four, and forty-eight hours. Pressure elements of various ranges may be used. The lowest range used thus far has a calibration of 75 lbs., and the highest has a calibration of 1,100 lbs. per inch of movement of the stylus. Temperature correction in most cases may be neglected. The chart reading will be approximately one pound low for each 65° F. increase in temperature. Although this instrument appears to be quite delicate, service in the field has proved it very rugged. Five charts taken in producing wells are reproduced in Figures 2 to 6, inclusive. The pressure scale and notes showing depths of readings and some of the changes in the well which caused a change in pressure have been added. The chart shown in Figure 2 was made in a well producing by gas-lift, flowing between 2½-in. tubing and 7-in. casing. The bottom of the tubing was 3,602 ft. and the top of the sand at 4,124 ft. Readings were taken near these depths before gas was injected to start the well flowing. The pressure of 558 lbs. recorded at 4,120 ft. was considered as the pressure in the producing formation. The pressure at the bottom of the tubing increased 26 lbs. after starting to inject gas, probably due to the weight of the gas under pressure. During the last five hours of the chart the well was flowing by heads at the rate of 1,560 bbls. per day, with an input volume of 940 M. cu. ft. and a trap volume of 1,600 M. cu. ft. per day. The chart shown in Figure 3 was taken in a well flowing by heads at the rate of 580 bbls. of oil per day, from 3,935 ft. through 8⅝-in. casing. The formation pressure at the top of the pay zone was 1,520 lbs. The rate of gas production which is plotted simultaneously with the pressure at the bottom of the hole was obtained with an orifice meter, using a fast meter chart. The time, pressures, and gas volume

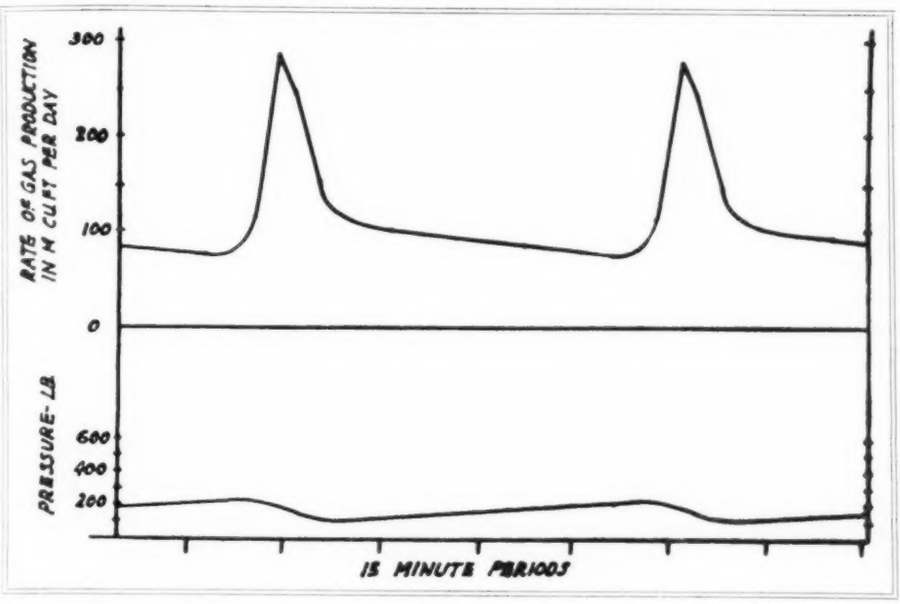

Fig. 3

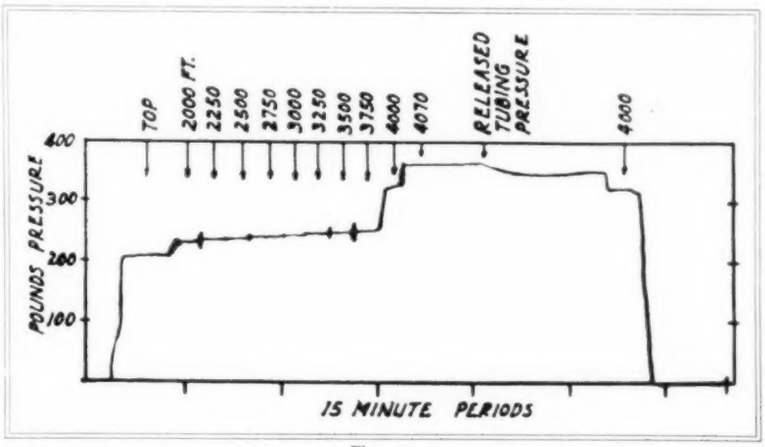

Fig. 4

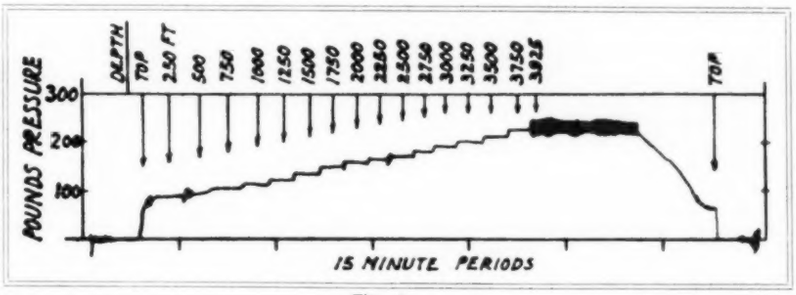

Fig. 5

were repeated with marked regularity during each flow. The chart reproduced in Figure 4 was taken in a well that had been flowing by gas lift, but was shut down at the time the chart was taken and still had a tubing head pressure of 224 lbs. The increase in pressure due to the weight of the column of gas is recorded down to 3,750 ft., where the pressure was 257 lbs. From the pressure increase in fluid between 4,000 ft. and 4,070 ft. and the pressure increase from the top to 3,750 ft. in gas, the point at which the gauge went into fluid is calculated at 3,830 ft. When the tubing pressure was released the pressure at the bottom temporarily dropped only 15 lbs., showing that the tubing filled with fluid almost as fast as the gas pressure in the tubing could be released. The chart shown in Figure 5 was taken in a well producing at the rate of 2,200 bbls. of oil and 2,500 M. cu. ft. of gas per day through 8⅝-in. casing. This chart shows pressures at intervals of 250 ft. in the flowing column of oil and gas. The excessive vibration of the gauge while at 3,925 ft. was probably caused by the gauge hanging opposite a stratum of pay sand. The chart reproduced in Figure 6 was taken in a pumping well and is explained in a later paragraph. These charts are representative of a large number that have been obtained in wells producing under a wide variety of conditions.

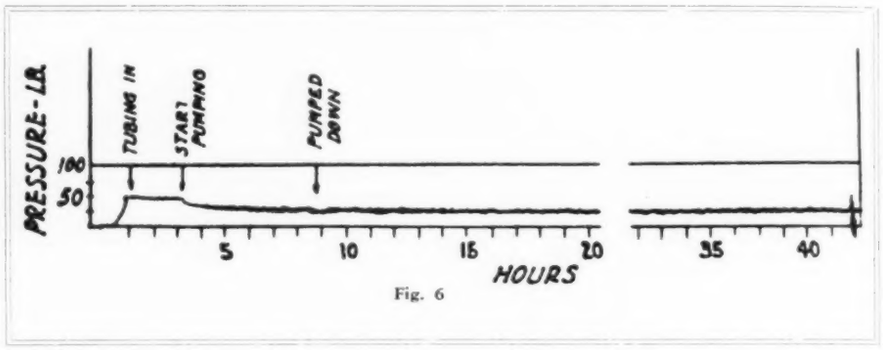

Fig. 6

Application of Bottom-Hole Pressures

The value of determining pressures in different formations while drilling through them is shown in the following table. These pressures were obtained in wells in the Carr City Pool in the Seminole District, Seminole County, Oklahoma:

Formation	Top feet	Bottom feet	Pressure lb.
Hunton	3980	3910	1520
Simpson	4068	4124	1152
First Wilcox	4124	4142	637*
Second Wilcox	4217		800†

*Simpson and First Wilcox open to hole.

†Estimated from increase in fluid level.

Measured pressures in these formations permit certain precautions which might otherwise be overlooked. For example, in drilling it is the universal practice in the Seminole District to produce the small amount of oil which may occur in the Simpson with the "First Wilcox" Sand. As these sands are usually drilled with cable tools, the much higher pressure in the Simpson would cause oil to flow from the hole into the "Wilcox" Sand when the porous part of the "Wilcox" is first encountered, and if the hole were not free from drill cuttings they might be packed so tight around the bit that a fishing job would result. It is not uncommon to find a large difference in the original pressures in formations that are separated by a relatively short vertical distance.

The formation pressures and the production of four wells for ten months are shown graphically in Figure 7. These wells are located in South Earlsboro Pool, Secs. 22 and 23, T. 9 N., R. 6 E., in Seminole County, Oklahoma. The pool is known to have encroaching edge-water forming a natural water flood, the static head of which is the same as the original pressure in the field. Under such conditions it is reasonable to expect the water to have considerable effect on the rate of decline of production and on the formation pressure in the area adjacent to any individual well. If the oil and gas are removed from the reservoir faster than the water encroaches, the formation pressure, and therefore the rate of recovery, will decline as in the first part of the curves for Edwards 2 and Grounds 2. When the production of oil and gas decreases to such a rate that water replaces it at the same rate as it is removed, both the formation pressure and the rate of recovery should be constant, as in Edwards 2 after July, after September in Grounds 5, and throughout Edwards 5. When the flood approaches the well, there will be an increase in the formation pressure and also the rate of production, as in Edwards 2 and Edwards 5 in January. When the water reaches the well, the rate of recovery will decrease and the pressure will remain constant or may increase as in Grounds 2 after November and Grounds 5 after July. While correlation of the oil produc-

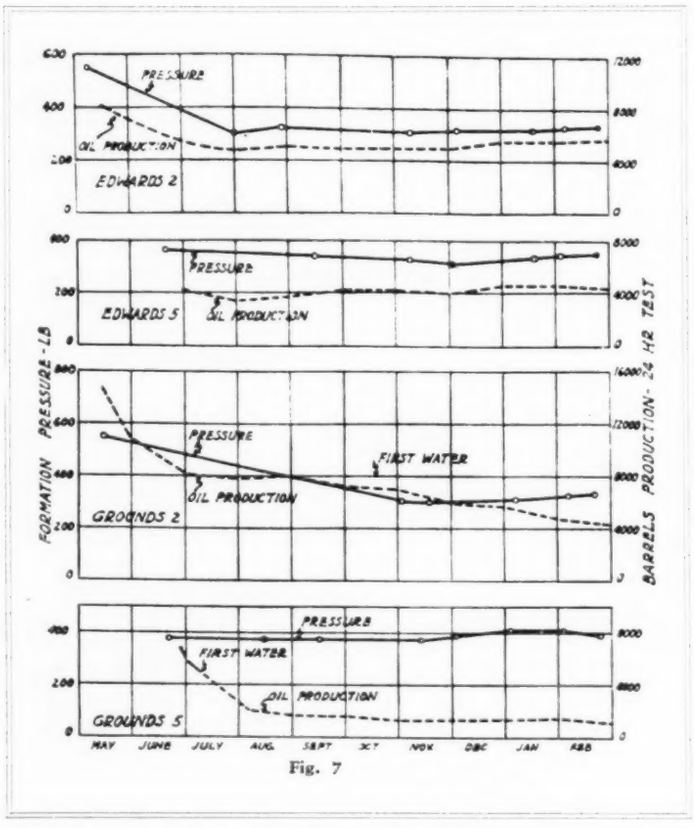

Fig. 7

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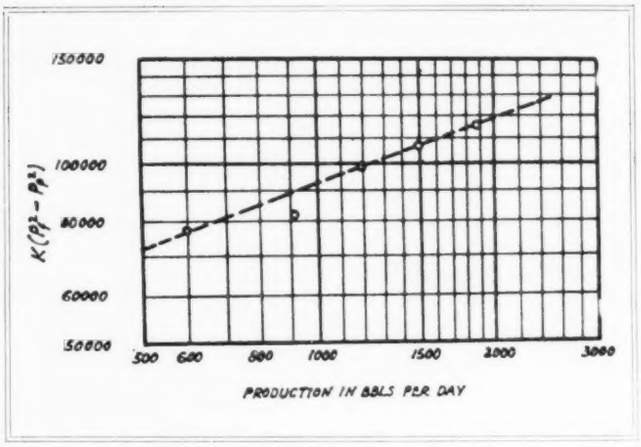

Fig. 8

tion, formation pressures and water encroachment in these wells is obvious, it is probable that if the bottom-hole pressure were available during each of the production tests, a correlation between the pressure differential in the formation and the rate of production would permit a broader and more definite interpretation.

Pierce and Rawlins[3] have determined a mathematical relationship of rate of production and differential pressure within the producing formation for gas wells. A similar correlation has been found in certain oil wells in the Yates Field and in the Seminole District. Moore has given other relations of the rate of production and pressure differentials in the sand.[4] Data on two wells in the Seminole district worked out according to the method of Pierce and Rawlins, are given in Figures 8 and 9. The data in Figure 8 were taken in a well producing from the Wilcox Sand where the formation pressure was 412 lbs., and in Figure 9 in a well producing from the Hunton Lime in which the formation pressure was 1,520 lbs. Pierce and Rawlins also found that when this rate of production was expressed by a curve that the slope of the curve did not change with depletion. While sufficient data have not been obtained to determine what the effect of depletion may have on the correlation in oil wells, it is believed that it may not be so simple as in gas wells. In gas wells the same fluid is moving through the sand at all stages of depletion, while in oil wells the characteristics of the fluid change as the production is depleted, principally due to a change in the absolute gas-oil ratio. Other differences of lesser importance, such as change in gravity of oil, and gravity of gas, including that due to some of the lower hydrocarbons which were originally in liquid state becoming gas, and change of size of drainage channels due to erosion within the producing formation may affect the correlation after some depletion has occurred. Even though the slope is changed, a correlation should still exist which can be expressed mathematically, but it will require more tests to determine than if the slope should remain constant. The application of this relationship in prorated fields should be especially important. Potential production might be established without opening any well to its open flow capacity. This would save gas, extra labor, and lessen the danger of bringing in bottom water. It deserves much attention in this connection.

[3] Pierce, H. R., and Rawlins, E. L., "The Study of a Fundamental Basic for Controlling and Gauging Natural Gas Wells," Part 2, U. S. Bureau of Mines, Reports of Investigations, Serial 2930, May, 1929.

[4] Moore, T. V., "Determination of Potential Production of Wells Without Open Flow Tests," Subtopic of "Improvement in Production Practice," by W. W. Scott, American Petroleum Institute, Eleventh Annual Meeting Proceedings, Section IV, p. 27.

The relation of rate of production, casinghead pressure, and bottom-hole pressure obtained from a series of tests at various rates of production are shown by curves in Figure 11. These tests were taken from a well producing from the Hunton Lime in the Carr City Pool, Seminole County, Oklahoma. They were made over a period of about two weeks, and were taken at random, rather than in the sequence of the plotted points. The pressure in the producing formation did not change any measurable amount during this period. Subsequent tests have not given the uniform relationship of casinghead pressure with bottom-hole pressures and rate of production that was obtained in this series. Similar data on a number of wells have shown that the correlation between the casinghead pressure and bottom-hole pressure is often indefinite and becomes more irregular as the bottom-hole pressure approaches the pressure in the producing formation.

Pressure gradients have been taken in wells flowing naturally and by gas-lift. Some typical gradients are shown in Figure 10. Additional well data, at the time these pressures were taken, are given in the following table:

Curve	Size of Flow String	Absolute Gas-Oil Ratio at Top of Well (Cu. Ft. per Bbl.)	Velocity at Top of Flow String (Ft. per Sec.)
A	8⅝"	28	1.2
B	8⅝"	36	0.4
C	8⅝"	68	56.5
D	8⅝"	104	81.6
E	8⅝"	669	35.3
F	7"	1065	141.5
G	5 3/16"	1420	94.4

Curves A, B, C, D and E are on the same well under different pressure conditions. The curves are plotted on

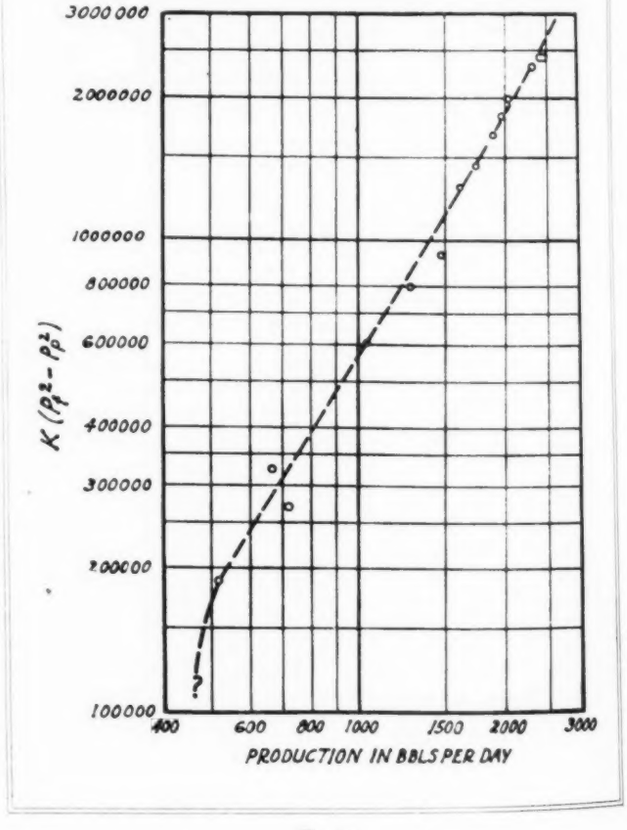

Fig. 9

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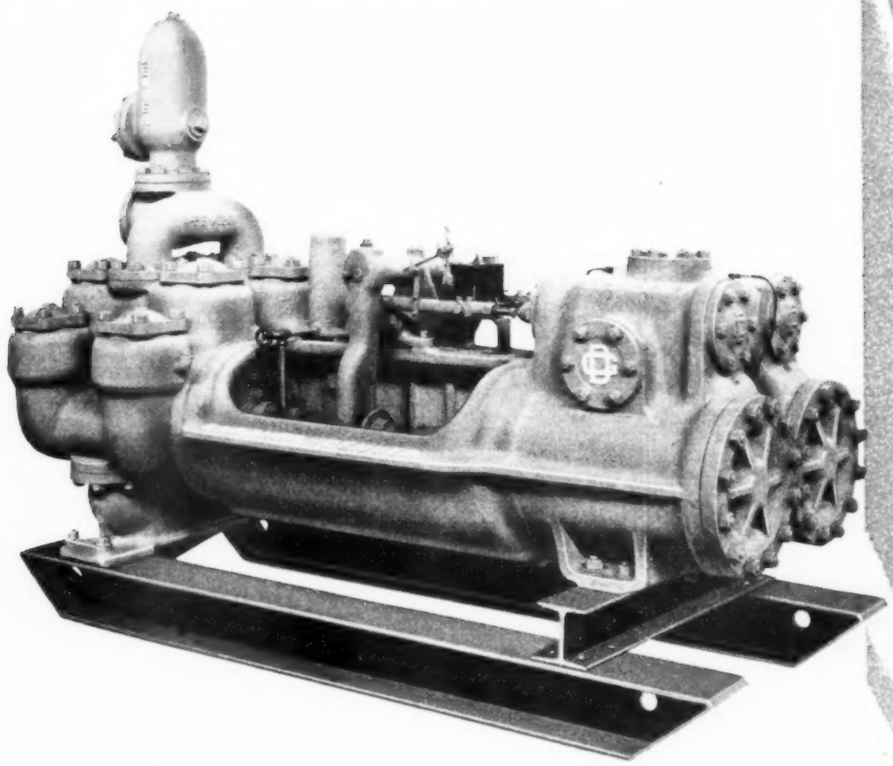

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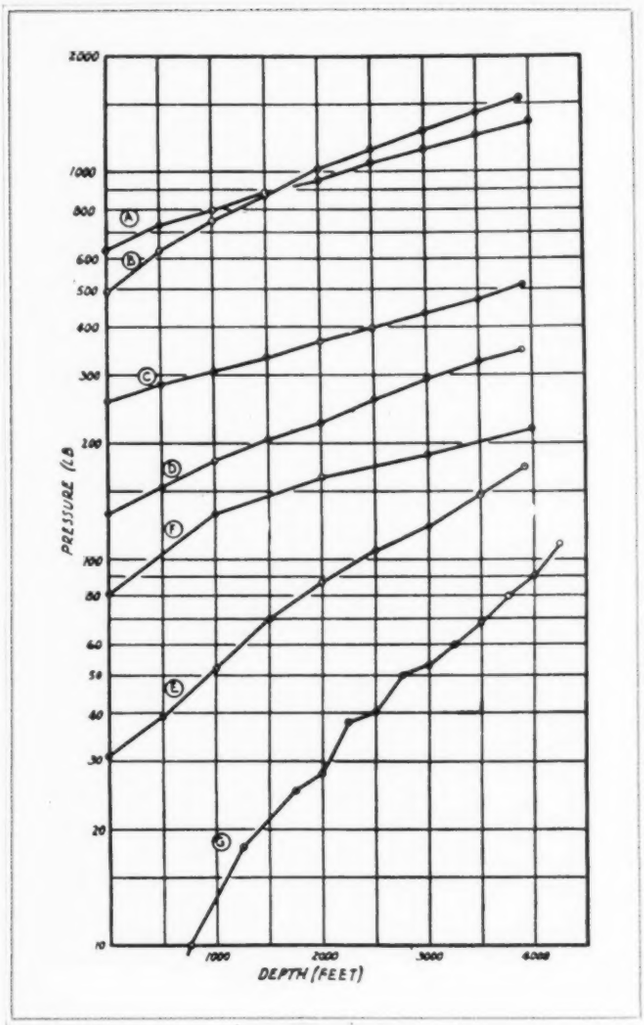

Fig. 10

semi-logarithmic paper and most of the points approach a straight line in the lower part of the flow string, but toward the top of the well there is a tendency for the gradient to become steeper except in Curve C. It suggests that the place at which this change occurs may be the place where the flow changes from viscous to turbulent. The velocity at this point probably varies with the absolute gas-oil ratio, because it shows up on the low as well as the high velocities. These curves indicate that the flow of oil and gas mixtures through vertical pipes is probably more regular and the loss in pressure less than is generally considered.

Bottom-hole pressures have been taken in pumping wells under operating conditions by placing the gauge in a perforated anchor below the standing valve. The chart obtained in one of these wells is reproduced in Figure 6. This well had been shut down for over twenty-four hours at the time this chart started and the pressure recorded was 53 lbs., which is considered as the formation pressure. After pumping five hours the pressure decreased to 30 lbs., which is 66 per cent of the formation pressure (absolute). The pressure did not change during the rest of the period of the chart (33 hours). During this time production averaged 16 bbls. per hour. Another well had a formation pressure of 69 lbs., and pumped 27½ bbls. per hour, with a bottom-hole pressure of 56 lbs., which is 84 per cent of the formation pressure (absolute). It is probable that the amount of oil pumped from each of these wells was limited by the capacity of the pump as it is unlikely that the maximum amount of oil was delivered to either well with so low a differential pressure in the formation. A knowledge of bottom-hole pressures in pumping wells will give as much data for solving recovery problems as in flowing wells. It will also give information as to whether the rate of production obtained is limited by the capacity of the pump or by the capacity of the sand to deliver oil to the well.

Summary

Production control and lifting procedure can be more intelligently directed when bottom-hole pressures and pressures within the producing formation are known. By comparing these pressures the operator may determine whether the rate of production being obtained is limited by the capacity of the method of lifting the oil or by the capacity of the well to produce. The best size of flow string for a well flowing naturally or by gas-lift must be determined by the use of an estimated, calculated, or measured bottom-hole pressure, and the degree of accuracy is in proportion to the accuracy of the bottom-hole pressure upon which the calculation is based. Production control used to obtain more efficient use of the gas energy accompanying the oil, to retard bottom water invasion, or to obtain more effective natural water flood, is usually accomplished by regulating the pressure at the casinghead or changing the operating method. These are indirect methods because a change in the rate of production is a result of change in the bottom-hole pressure (more specifically a change in the differential pressure between the producing formation and the bottom of the hole) caused by a change of the casinghead pressure or method of operation. Reliable pressures at the bottom of oil wells and in the producing formation are essential in solving problems of lifting and recovery of oil.

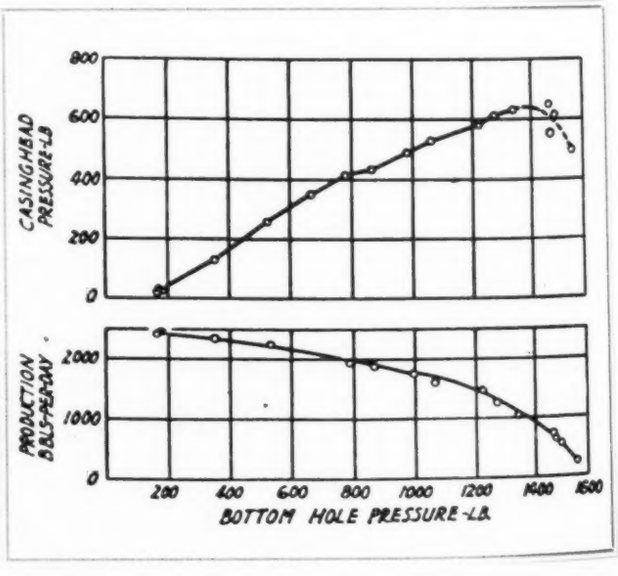

Fig. 11

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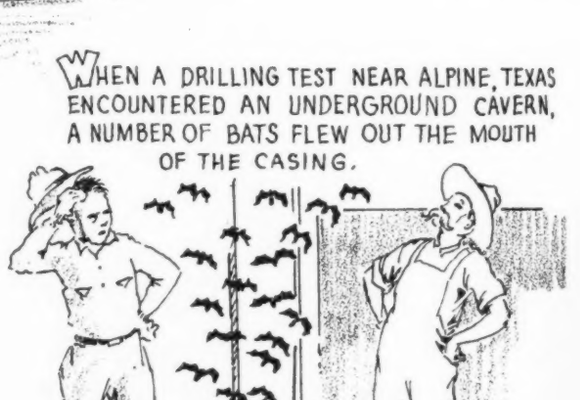

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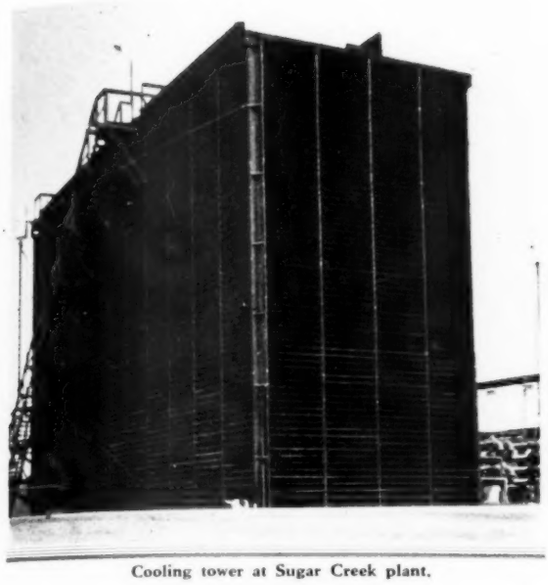
In your experience in the oil industry you have heard described or witnessed "strange but true" happenings worthy of publication on this page. All contributions will be gratefully received and credit given for each.



Cooling tower at Sugar Creek plant.

OPERATION *of a* High Pressure Gasoline Plant *at Sugar Creek, La.*

THE high-pressure absorption type natural gasoline plant completed and put into operation during January of this year in the Sugar Creek field, La., illustrates the splendid progress made by the engineer in the design and construction of an efficient plant to meet special operating conditions. In order to meet variations in the volume and pressure of the gas or in its gasoline content and to manufacture various grades of natural gasoline, the equipment was designed so that it would be flexible enough in its operation to meet any conditions encountered.

The plant was built for the Standard Oil Co. (La.), the Louisiana Gas and Fuel Co. and the Triangle Drilling Co. Its normal capacity is 30 million cubic feet per day, with a peak capacity of 45 million cubic feet at pressures as high as 500 pounds per square inch. The gasoline content of the gas is approximately one gallon per 1,000 cubic feet. The natural gasoline produced is sweet and non-corrosive; consequently no treating plant is required.

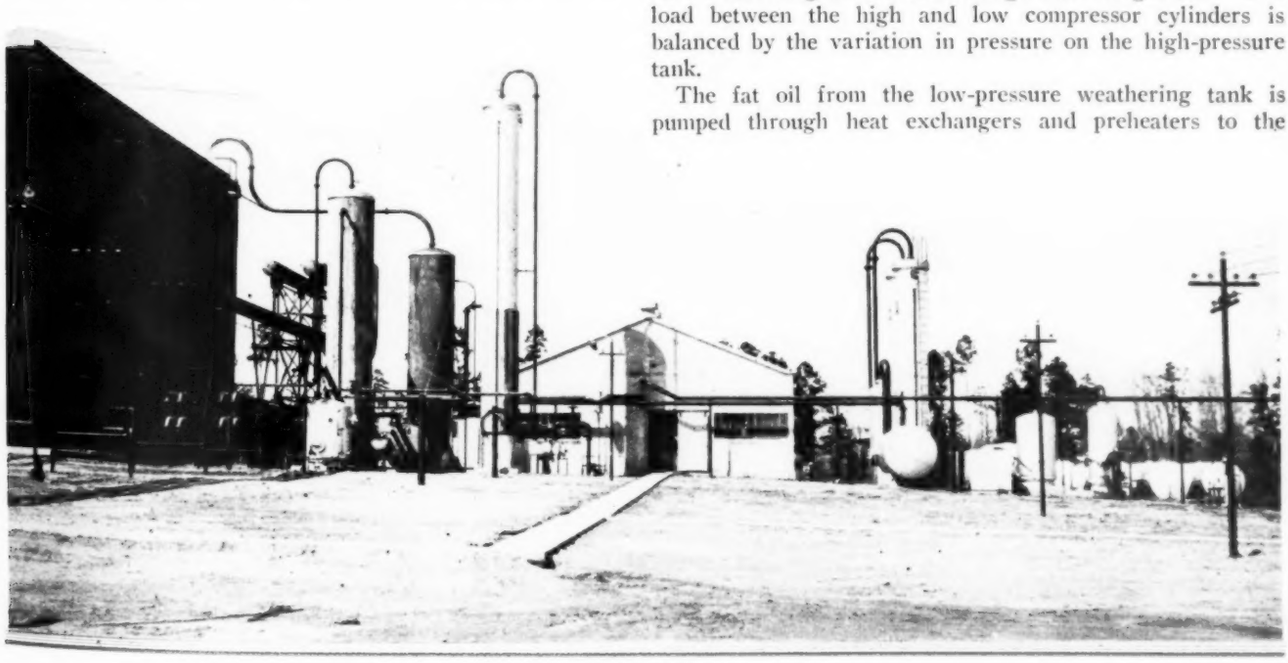
The accompanying flow diagram shows the layout of the various equipment in the plant and the flow of gas and liquids during plant operation.

The gas passes through a scrubber and then to the absorbers of which there are two each 48 inches in diameter and 30 feet high, and having 16 frothing sections in the hammer-welded shells. The shells are made of 1½-inch steel plate and are equipped with removable heads bolted to flanges on the shell. The residue gas passes through a scrubber at full plant pressure.

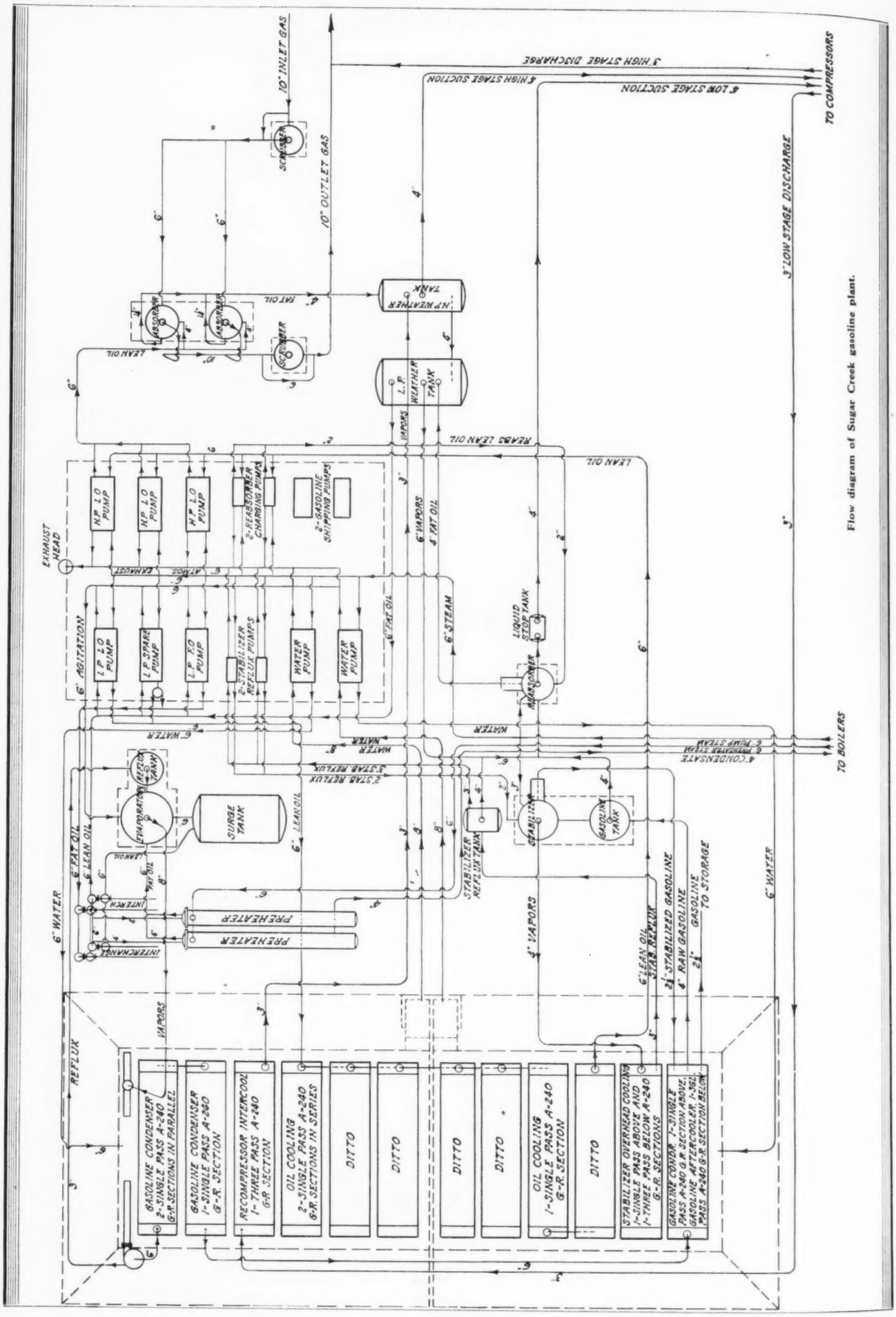
A two-stage weathering system is used in the plant. Considerable quantities of fixed gases dissolve in the oil in the absorbers, and compressors are used to pump these gases into the line. The fat oil from the absorbers enters the high-pressure weathering tank, which is equipped with a level flow control and a back-pressure regulator maintains a constant pressure. The oil then goes to the low-pressure weathering tank, in which the liquid level is controlled by a steam regulator on the fat oil pump. The controller maintains 30 pounds back pressure on the tank, and the fixed gases in the oil are released in two stages from the weathering tank. The uncondensed gases from the condensers are released into the low-pressure weathering tank.

Two 200-horsepower gas engine-driven compressors are used for recompressors. They take suction on the low-pressure weathering tank and discharge into the high-pressure weathering tank after passing through cooling coils. The high-pressure cylinders take suction on the high-pressure weathering tank and discharge into the gas line. The load between the high and low compressor cylinders is balanced by the variation in pressure on the high-pressure tank.

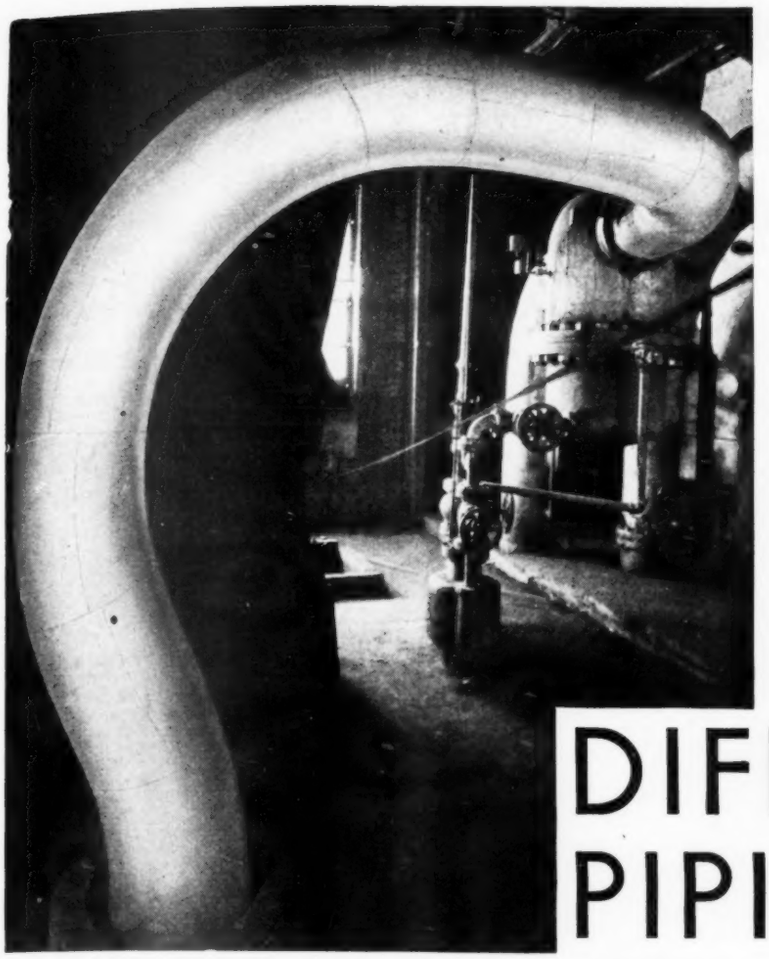
The fat oil from the low-pressure weathering tank is pumped through heat exchangers and preheaters to the



General view of plant.



Flow diagram of Sugar Creek gasoline plant.



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Works: East Chicago, Ind.
St. Louis Kansas City, Mo.
Detroit, Michigan

LIMBERT PIPING

When writing Geo. B. Limbert & Co. *please mention The Petroleum Engineer*

evaporator, the stripped oil goes to a surge tank, through heat exchangers and to the low-pressure lean oil pump and is then pumped through the coolers. Finally the high-pressure lean oil pumps then return it to the absorbers. The steam preheaters are elevated over the heat exchangers, which saves space and allows the condensate to gravitate back to the boilers.

Vapors from the evaporator go to the dephlegmator, which consists of 24 passes of two-inch copper bearing pipe lying in a horizontal plane in a flat wood box on top of the cooling tower. These are built along both sides and across one end of the structure, the pipes being partly submerged in the water in the box. The roof of the box is made of removable sections. The amount of submergence determines the temperature of the outgoing vapors, while an automatic thermostatic control regulates the water supply to the box. In this simple manner a substantial portion of the plant's total heat load is liberated into atmosphere, easing the load on the cooling tower proper.

The gasoline vapor from the dephlegmator is separated by a screen mist extractor. The condensate flows down to a reflux separator, where the water is separated and drained. The reflux oil gravitates to the top of the evaporator, and the gasoline vapors flow to the condensers located in the cooling tower. The condensate then flows to a water separating tank.

The raw gasoline is stabilized in an 18-plate tower operated at 35-pound pressure.

All low pressure vapors are processed in a re-absorber which contains 24 plates. This unit is operated and controlled automatically. It contains a heating element, an absorbing section and a fractionating section. Lean oil is circulated over the top of the unit. The unit treats overhead vapors from a stabilizer, uncondensed vapors from the gasoline condensers, and vent gases from the low-pressure weathering tank.

Cooling Tower

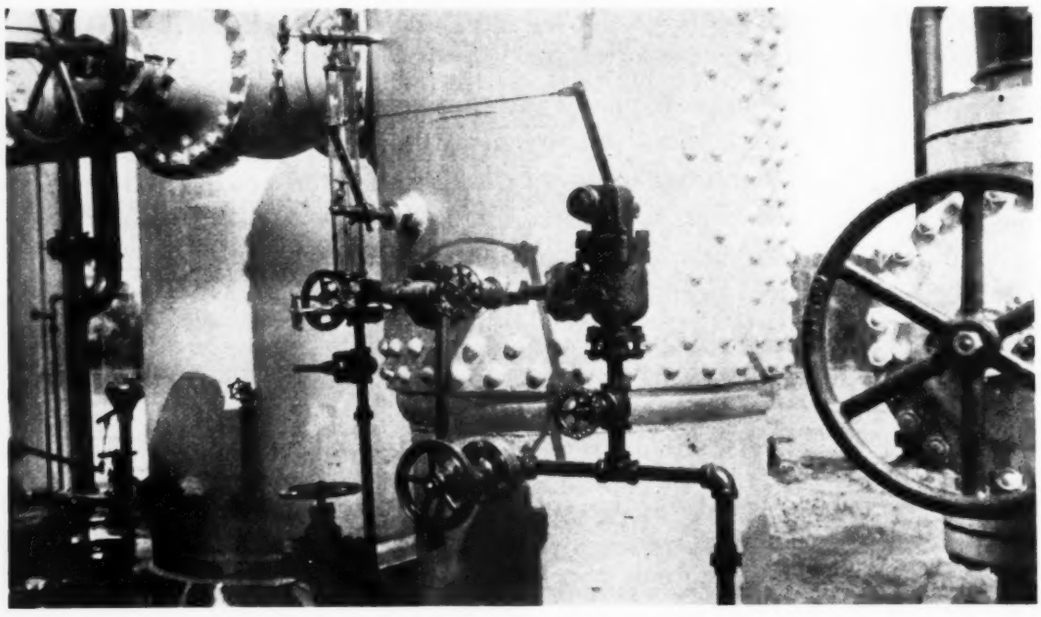
The cooling tower is 72 feet long, 22 feet wide and 42 feet high. It is of the narrow louver, deckless type. Water is distributed by means of spray nozzles directed downward and adjustable. A strong downward draft is induced through the tower by this type of construction. It is advantageous and effective for the low wind velocities and high wet bulb temperatures encountered in this locality.

A concrete dam is installed across the center of the tower. All hot materials are brought into one end for initial cooling. Here the extremely high temperatures are disposed of and the material then passes to the other end of the tower to finish cooling in an atmosphere free from steam and under conditions more favorable for close approach to the desirable wet bulb. A separate water piping system is used. There is a marked difference in the temperature of the water in the two basins. All cooling is done through the use of open cooling sections, installed in the base of the cooling tower.

Three water tube boilers generate steam for the plant. One boiler acts as a spare. Automatic control instruments are used on the gas supply and for the water level. The boilers are operated under 150-pound pressure. Water for the plant is obtained from two wells, each about 400 feet deep. The high-pressure gas is used as a lift to raise the water in the wells. The boiler feed water requires no chemical treatment.

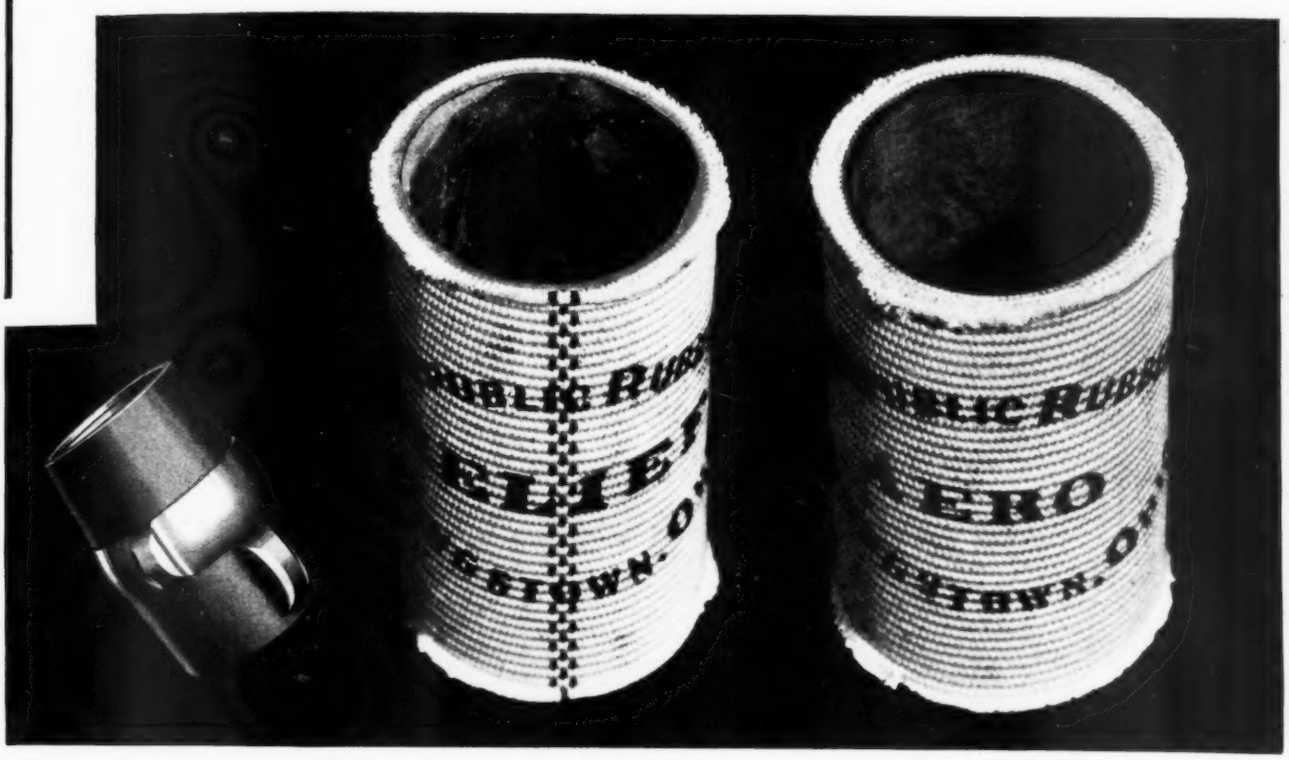
The finished gasoline is stored in a battery of four horizontal tanks, each 25,000 gallons capacity. A fifth tank in the battery is used for absorption oil storage.

The gasoline is loaded six miles from the plant at a four-car loading rack equipped with a vapor recovery system. The gasoline is gravitated to the cars from two 25,000-gallon storage tanks. A small compression system compresses the recovered vapors to 125 pounds after which they are condensed in a cooling tower. The liquid enters an accumulator and is then transferred to gasoline storage tanks.



Liquid level controllers on absorbers.

FIRE HOSE



OTHER REPUBLIC PRODUCTS

Transmission Belting
A. P. I. Drilling Belting
A. P. I. Pumping Belting
Conveyor Belting
Acetylene and Oxygen Hose
Chemical Hose
Distillate Hose
Fire Hose
Gasoline Hose
Rotary Hose
Oil Suction and Discharge Hose
Oil Conducting Hose
Steam Hose
Water Hose
Extruded Rubber Sleeves
Stuffing Box Rings
Swabs
Packers
Packing
Valves

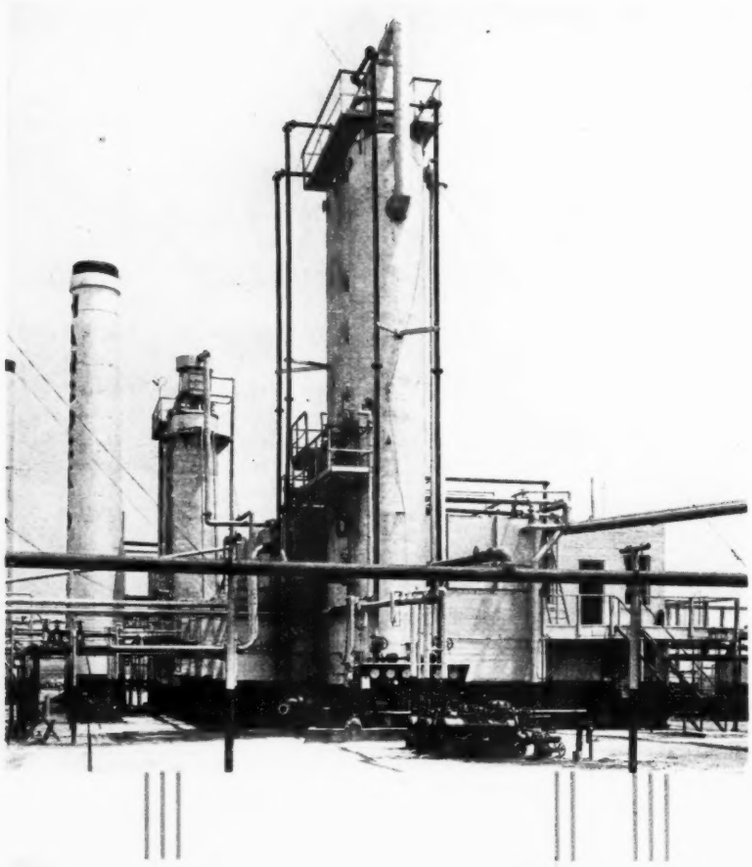
THE ingredients, the formula and the workmanship that goes into Republic Fire or Mill Hose—whether it be single or double jacket—is of a quality that exceeds absolute necessity. Better materials and workmanship are bound to produce a better product—and Republic has built this outstanding hose, knowing that a better product would build everlasting good will.

THE REPUBLIC RUBBER COMPANY

YOUNGSTOWN, OHIO

When writing THE REPUBLIC RUBBER CO. *please mention The Petroleum Engineer*

Hancock Has *in* California



PERHAPS more attention than ever before is being given to the general appearance of the refinery by managers and superintendents. Safety and efficiency are the results of well-kept equipment and a neat, clean plant. An excellent example of this type of plant is shown by the accompanying illustrations.

The refinery of the Hancock Oil Co. of California is located at Signal Hill, in what might be called "the heart of the California petroleum industry." The company has production and proven acreage in Signal Hill, and also at Huntington Beach, Maricopa, Kettleman Hills and Carpenteria. The refinery is located on a tract of approximately 23 acres. It has a daily capacity of 15,000 barrels and, with the storage at its Marine Terminal, has storage facilities for approximately one million barrels.

The crude, after passing through the heat exchangers, is run through eight 2000-barrel pipe stills. From the stills there are two batteries of fractionating towers, taking off various cuts: gasoline, kerosene, gas-oil and residuum. These cuts are all made by automatic temperature control, which holds the temperature as close as two degrees F. The gasoline and kerosene run through the look boxes in the receiving house and then, after treatment, to the rundown tanks. Gas-oil and residuum are run to large storage tanks.

All the light oil and crude storage

Top—Pipe still and fractionating towers.
Left—Loading rack.

General view of Hancock Oil Company

Model Plant

By

H. A. NEW

tanks are equipped with a vapor recovery system which collects all gasoline fumes which would be wasted and converts them into a gasoline of very high anti-knock properties.

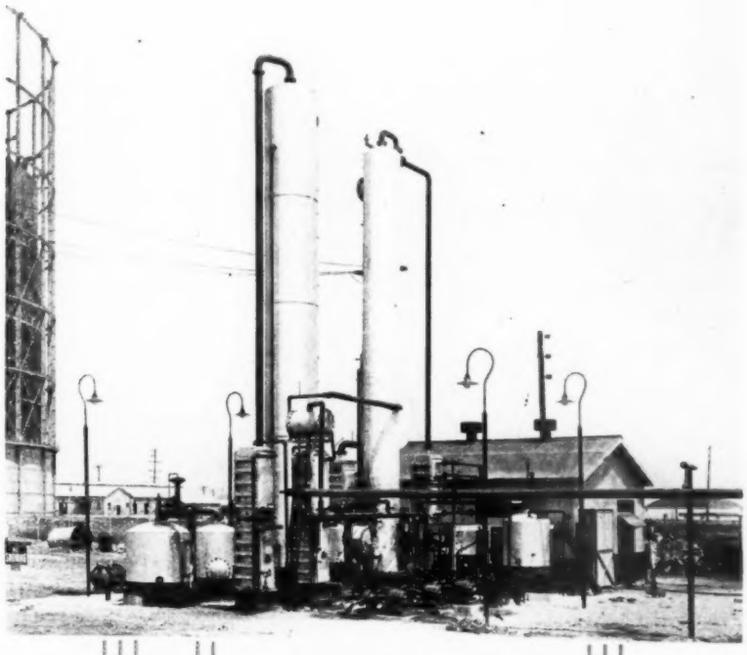
The gas-oil and residuum, or fuel oil, are pumped to the company's Marine Terminal at Los Angeles harbor, where there is also a blending plant to make Diesel oil. Motor-driven centrifugal pumps deliver the products from the refinery to the terminal. The total rated cargo pumping capacity of the terminal is 24,000 barrels per hour. The capacity is 14,000 barrels for white oils and 10,000 barrels for black oils. The motors are directly connected to the centrifugal pumps through a concrete fire wall.

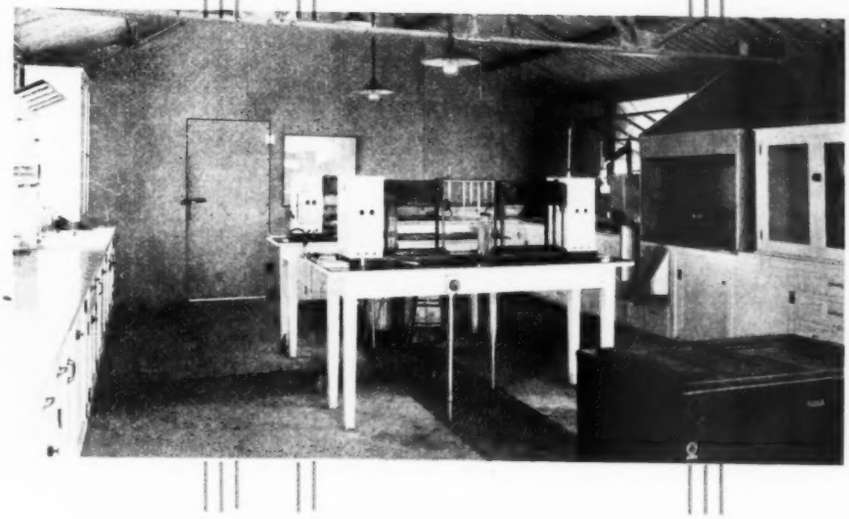
The entire terminal and dock are equipped with the most modern type of fire-fighting equipment. A fire foam unit is installed at the terminal.

The tank storage capacity of the terminal is 275,000 barrels, and total storage facilities of the company are approximately one million barrels.

Gasoline is pumped to the terminal for marine shipment, while tank car and truck shipments are made direct from the refinery.

The high quality of Hancock products is maintained by careful refinery control and continuous tests in its complete testing and research laboratory. The company maintains its own service stations and a fleet of trucks.



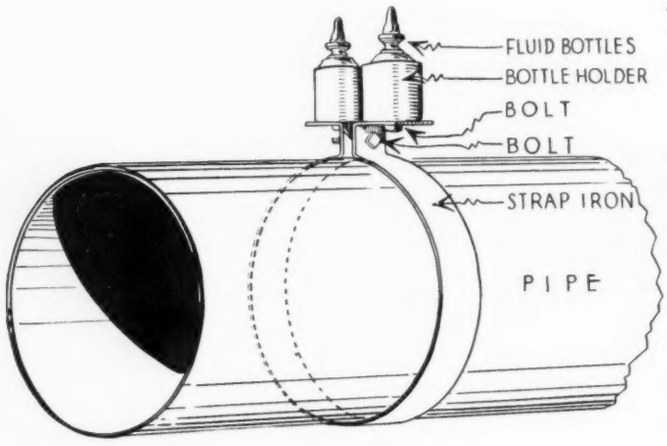


Top—Vapor recovery unit.
Right—Chemical laboratory.

refinery, Long Beach, Calif.

TIME *and* TROUBLE SAVERS

WHERE recording gauges are used frequently, no provision is made for safe-keeping of ink bottles. Consequently, sills or corners where bottles are kept are usually unsightly with ink stains, and often the bottles are knocked over and the contents spilled.



A safe receptacle for the bottles may be easily made with a piece of strap iron. It is fashioned to fit around the pipe on the meter run near the recorder. Bolt holes are drilled in the neck and the receptacle may be bolted tight to the pipe with a bolt inserted in these. The top part of the holder is bent to right angles and small bolt holes drilled in the center of the flat tops of these. The shipping container of the bottles is bolted to the flat top and made more rigid with a wide washer. Bottles are kept inside of the shipping container.

The same principle may be used to fashion a key holder for the lock on the recording meter. It may be attached to one of the small lines on the meter and the key inserted in a drilled slot.

A convenient method of pulling heat exchanger bundles is to erect an I-beam in front of the bundle and parallel to the exchanger, use the I-beam as a trolley for a couple of chain hoists, plant a dead man several feet ahead of this hook-up and use a set of blocks to pull the bundle.

A recording thermometer placed in the plant water circulating system and installed in the control room so that the stillman can be required to make a record of the hourly temperature will detect trouble in the cooling system instantly.

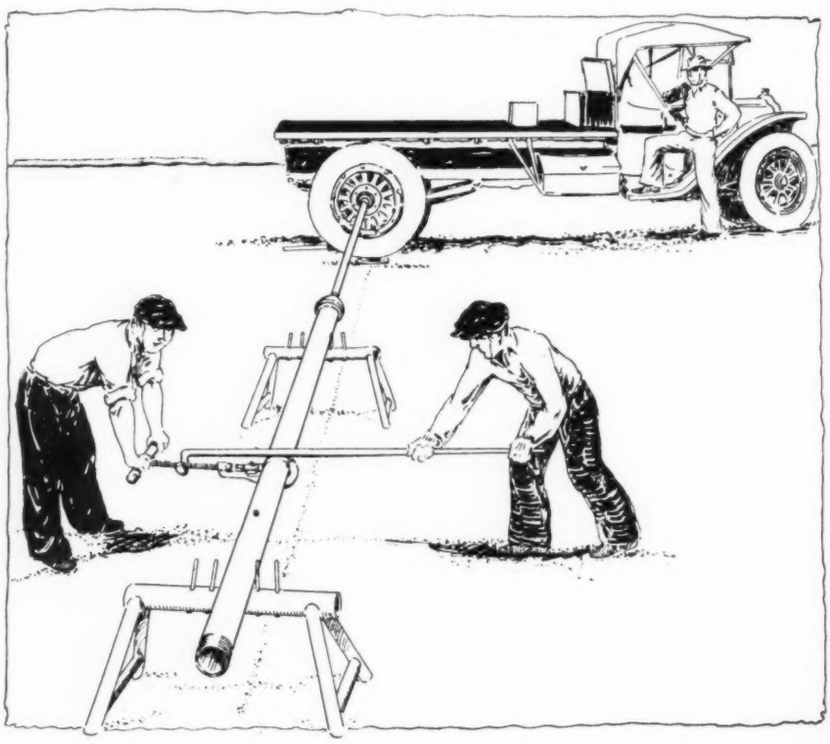
Installation of a recording or indicating thermometer in every stripping section of the bubble towers will indicate trouble in the tower at once. This is especially valuable when trays coke up.

C. M. COPELAND, Comar Oil Company, district superintendent at Tonkawa, Okla., has equipped a motor truck to aid the connection gang in cutting and threading pipe.

The regular hub cap on the right rear wheel was removed and one with a projected socket was improvised, into which a driving bar about six feet long is inserted. The other bar end has a square socket to fit over the ratchet on the dies. Two "horses" the same height as the truck hub complete the outfit.

For cutting, a socket is slipped over the end of the pipe from which the driving bar is connected to the truck wheel. An ordinary pipe cutter is placed on the pipe and held in place by a long handle hook placed over the pipe to the cutter handle. The jacked-up truck wheel turns the pipe and as it is turned an operator feeds it on the cutter.

In threading, a die is placed on the pipe and connected to the truck by the driving bar. The outfit is operated as if cutting. When the thread is cut, the truck is put in reverse and the die backed off.



This New Oxweld Type W-17 Welding Blowpipe

is but one of many in the complete Oxweld line, which includes blowpipes, regulators, welding rods and supplies for every oxy-acetylene welding and cutting operation. Phone or write the nearest Linde District Office for more complete information.

Why Does Industry Pay More For Oxweld?

OXWELD welding and cutting apparatus costs more per unit than any other type. Yet in 1930 more Oxweld apparatus was sold than any other make. There must be sound reasons behind Industry's willingness to pay more for Oxweld.

Oxweld apparatus insures the purchaser the greatest value his money can buy. Behind it are broadest manufacturing experience, scrupulous attention to details of design and engineering, and strict adherence to the policy that quality and performance are of first importance.

Oxweld blowpipes embody the Oxweld low-pressure injector principle, which automatically maintains the correct mixture of gases, thus effecting important savings of materials and time. In addition, Oxweld blowpipes are light, finely balanced, have smooth-working valves, and each head has its own injector and mixing chamber.

Oxweld stem-type regulators contain fewer working parts than any other type. Their simple construction enables the operator to change the valve seat without special tools. They are exceptionally rugged and dependable, but when necessary, reconditioning may be done on the job at a total parts cost of only $1.80.

Measured in terms of operating economy and performance Oxweld represents maximum value in welding and cutting apparatus.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

126 Producing Plants UCC 627 Warehouse Stocks

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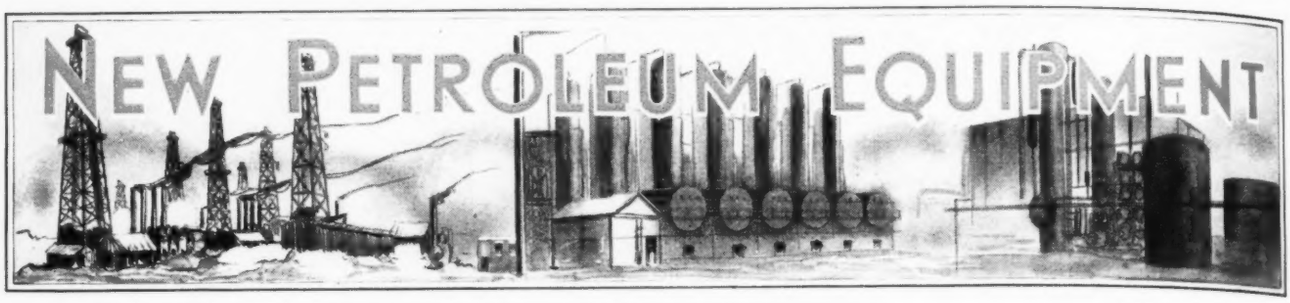
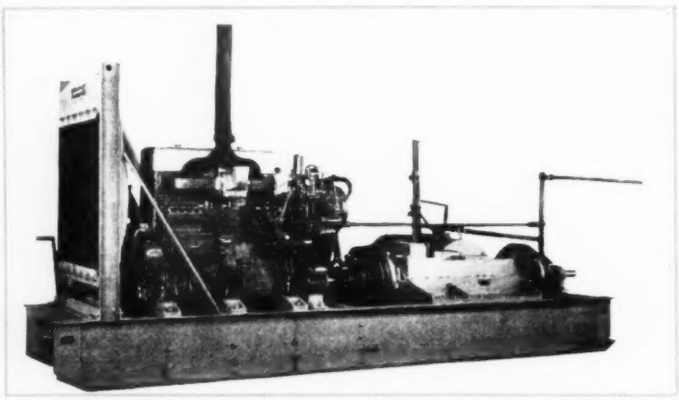
When writing THE LINDE AIR PRODUCTS COMPANY *please mention The Petroleum Engineer*



Portable Diesel Drilling Unit

THE Young Engine Corp., of Canton, Ohio, announces the introduction of a portable drilling unit. Foremost among the advantages, which appeal to cable tool drilling rig users, according to the makers, are the savings which can be made.

The power plant of the Model 120D Young Drilling Engine is a Buda M. A. N. D. 4-30 6½x8¾, four-cylinder, four-cycle type. The motor construction is such that it may be operated on either two or four cylinders. This permits using the power at the highest point of efficiency, by cutting out two cylinders when running light and holding in reserve the other two for such times as full power is needed. To facilitate starting, a small air-cooled gasoline engine is mounted to the frame in a way similar to a starting motor. As soon as the large motor is in motion the small engine cuts out.



A cast transmission case encloses the spiral cut, alloy steel, heat-treated, noiseless gears which are mounted on six Timken bearings, two adjacent to the forward clutch, two at the rear and two on the bevel gear shaft. The clutches are connected so that it is impossible to throw in either one without releasing the other. By an ingenious link arrangement a brake is applied as one clutch disengages and automatically releases as either clutch is thrown in. The brake is unusually rugged with a drum 20 inches in diameter and a 5-inch face.

One of the outstanding features of this drilling engine, in addition to the economy of operation, is the mobility of the unit. Self-contained on a rugged structural steel welded frame, it requires only a light, inexpensive foundation and can be moved from place to place with practically no time lost in dismantling. The narrow frame is an outstanding advantage, especially on hillside operations.

C-E Stoker Unit

COMBUSTION Engineering Corporation, 200 Madison Avenue, New York, has recently placed on the market the C-E stoker unit, which is a self-contained underfeed stoker with electric drive and integral fan construction.

This stoker has been developed to provide a simple automatic machine for the firing of small boilers up to 150 horsepower. It has a number of important features, such as agitated grate bars, side dumping grates and agitated feed hopper, eliminating arching of the coal and interrupted feed.

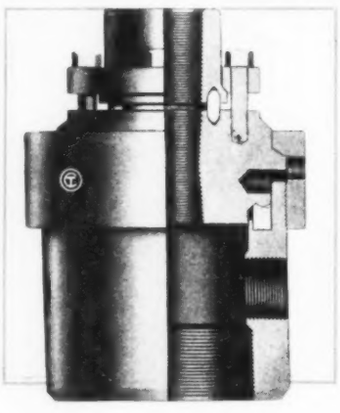
The design is self-contained, completely enclosed and provides a simple, rugged and dependable unit for the underfeeding of coal under small boilers. Three sizes are available, with coal-burning capacities of 300 pounds, 600 pounds and 1000 pounds of coal per hour, respectively.

A folder has been prepared by the Combustion Engineering Corporation which gives full details of the machine.

OCT Combination Tubing Head

THE Oil Center Tool Company, Inc., Houston, Texas, has announced the development and production of the OCT Combination Tubing Head, tested to 3,000 pounds, for use on flowing or pumping wells.

The design of the head is simple and substantial with ample provision for tight, leak-proof joints. The top of the head is constructed so as to allow swivelling of complete Christmas tree, permitting all threads to be made up tight and flow-lines to be run in any desired direction. When tubing is pulled, it is only necessary to remove bolts from swivel flange and lift Christmas tree off. It is not necessary to disconnect a single thread.



The joint of the swivel flange incorporates the same sealing principle as that in OCT "Double-Seal" forged steel flange unions. A soft steel ring tapered on each edge fits into grooves tapered to correspond. This gives two independent seats and two seals. Either seal will hold the full pressure for which the head is designed.

OCT combination tubing heads are furnished for 6⅝-inch O. D. and 7-inch O. D. closing with either three or four-inch top connection.

HAVE you ever seen a cut-away Tube-Turn? You can see *and measure* the difference for yourself!

Tube-Turns are neither bends, castings, nor stampings. They are forged, by a patented process, from seamless steel tubing. *They have uniform walls.* There is no thinning of outside walls—no thickening or buckling of inside walls—no flattening of cross-section.

Being forged and annealed, no internal stresses or strains are set up during manufacture—there is no tendency to distort or fail under heat or pressure. . .

Having uniform walls, and being made of the same material as the pipe in the line, they have the same coefficient of expansion and contraction . . . they resist corrosion . . . they are as strong or stronger than the pipe itself. Since there is no buckling or flattening, Tube-Turns cause less pressure-drop. . . Being free from flanges or shoulders, they weigh less, can be nested closer and are far easier to insulate. . .

Tube-Turns are manufactured in *all* the sizes required for modern piping—from ¾″ to 18″ Standard I. P. S. and from 1½″ to 12″ Extra-Heavy I. P. S.

They are *stocked,* not only in 90° elbows, but also in 45° ells and 180° returns. They match Standard and Extra-Heavy I. P. S., respectively, in O. D., in I. D., and in wall thickness.

The standard radius of all stock Tube-Turns is 1½ times the nominal pipe size, which is the most practical radius for the reduction of pressure loss and for facilitation of designing and installation.

Tube-Turns are installed in the line with easy welds straight across the pipe. *They require no more rod, gas or labor than is consumed in the welding of straight pipe.*

Tube-Turns have proven advantages for every kind of piping job. If you want to get *all* the facts about this newest, simplest, safest and best way to make direction-changes in your piping, write for Bulletin 103. No obligation, of course.

TUBE-TURNS, *Incorporated*
1307 Shelby St, Louisville, Ky.

MEASURE THEM YOURSELF

A 45° and a 90° cut-away Tube-Turn, 2½″ Standard I. P. S. Note uniform walls and freedom from buckling or flattening.

TUBE-TURNS

The Seamless Fittings for Pipe Welding

When writing TUBE-TURNS, INC., *please mention The Petroleum Engineer*

Orifice Disc Housing

PACIFIC PIPE & SUPPLY CO., Los Angeles, has placed on the market the Papico orifice disc housing. The fitting is a simple plate container provided with a unique locking device for holding the disc. This housing is used where the meter installation includes a by-pass. The advantages claimed are that orifice discs may be easily and rapidly changed without having to loosen and take out the many bolts of a pair of flanges and then spread them apart, either with jack screws or wedges. It is claimed by the manufacturers that this feature is of particular value where the line size is larger or where the meter run is placed close to a wall or on the ground.

It is not necessary to carry a new style of disc on hand, as standard type plates may be used.

A complete description may be had on request to the Pacific Pipe & Supply Company.

Axelson Liner Insert Pumps

FEATURES of the Axelson Traveling Type Liner Insert Pump, manufactured by the Axelson Manufacturing Co., Ltd., Los Angeles, Calif., include the incorporating of liners in an insert pump, elimination of cups in insert pumps, and the adoption of the liner and steel plunger features from the liner type pump. The insert features of the traveling tube type pump, together with its decreased power cost, are likewise embodied.

Through means of special cage construction, the Barnwell plunger principle has been built into the traveling type liner insert pump. The beveled upper lip of the Barnwell type cage forms a wiping edge that removes all sand from the liners, preventing abrasion between the plunger and liners. The Barnwell cage is ground on the outside and, in reality, serves as a close-fitting extension to the working surface of the plunger.

The complete pump is installed with rods, eliminating the necessity of a tubing job, the manufacturers claim. Liner insert pumps are furnished with the improved Ritter "hold-down" or a cup "hold-down". Unless otherwise specified, these pumps come equipped with the Ritter "hold-down" which incorporates an expanding steel lock ring engaging with a recess in the Ritter shoe.

This pump is furnished in 9, 12 and 15-foot lengths for 2, 2½ and 3-inch tubing. The 9-foot length with a 48-inch plunger permits a 3-foot working stroke, the 12-foot permits a 6-foot working stroke and the 15-foot permits a 9-foot working stroke. In each case one foot has been allowed for spacing at both upper and lower limits of the barrel travel.

For complete details of this new Axelson pump, inquire of the Axelson Manufacturing Co., Ltd., at P. O. 337, Los Angeles.

New Recording Instrument

A NEW circular chart recording instrument, identified as Type A, has been announced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. These instruments are light and small; they include ammeters and voltmeters, and are made for switchboard mounting or as portable instruments.

They are designed principally for alternating-current applications, but are also applicable to certain direct-current services. The ammeters are available in sizes ranging from 5 to 50 amperes and give a full-scale reading from zero to the value at which the meter is rated; voltmeters are made in ratings varying from that which provides a scale of from 90 to 140 volts to that which records a maximum voltage of 550 volts.

An example of their utility is for determination of the most economical use of motor-driven machinery and the loading of motors.

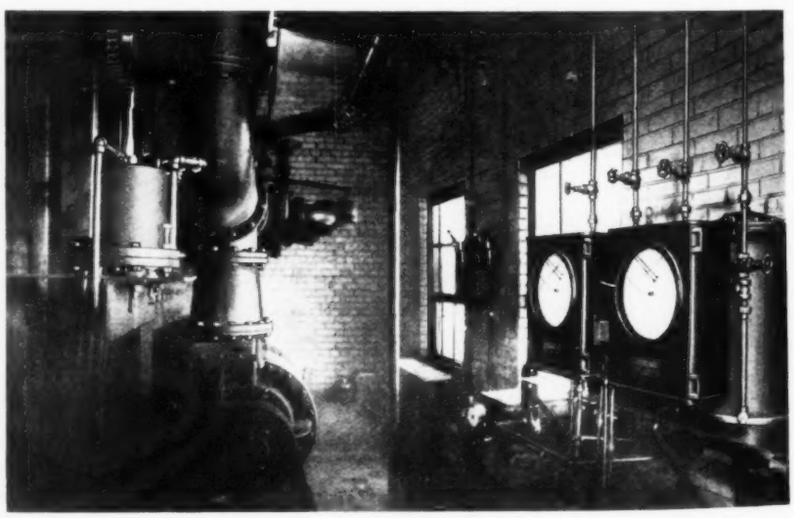
Full details of the specifications and operation of this new circular chart recording instrument may be obtained from the manufacturers.

Automatic Ratio Control

A RATIO control for the mixing of gases or liquids in any desired proportion has been announced by the Bailey Meter Company, Cleveland, Ohio.

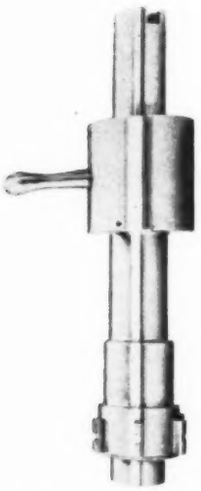
Air and fuel for combustion in industrial furnaces may be automatically proportioned by this control so as to secure maximum fuel economy. A control of this kind can be applied to both liquid and gaseous fuels or to a combination of the two in such a way as to insure the highest combustion efficiency consistent with economical operation. Mixing of two or more gases or liquids to form a low-cost fuel can also be accomplished by this control.

Any desired ratio between the component parts of a mixture can be secured by selecting the proper ratios for the meter orifices. A further adjustment or change of ratio can be had by use of the ratio changing device, which is simply a movable pivot supporting the linkage in the right-hand meter casing.



Full details of this automatic ratio control can be secured by writing to the Bailey Meter Company.

Victor Valve Seat Tap



THE Landis Machine Company, Inc., at Waynesboro, Pa., has developed and placed on the market a unique tap for tapping the valve seat ring threads in gate valves.

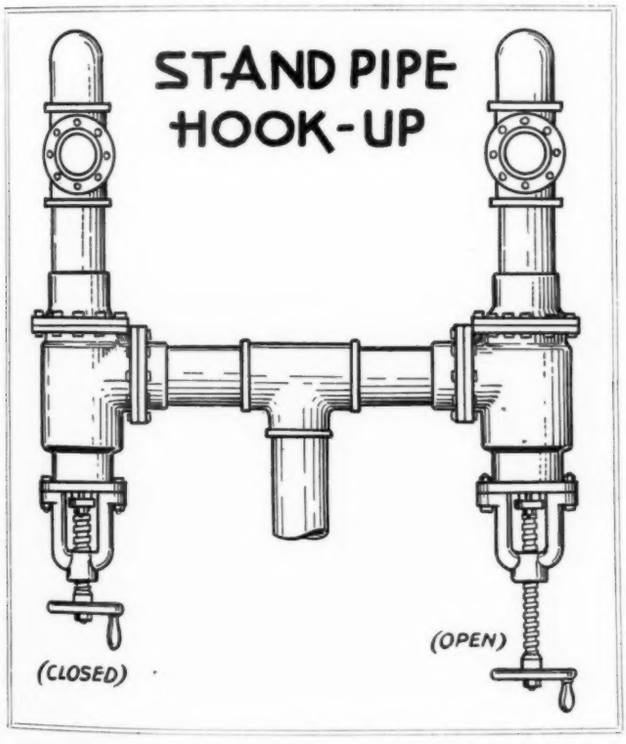
The Victor Valve Seat Tap is fitted with double ended chasers, one end for each of the two valve seat ring threads. Its construction is such that the chasers, when collapsed, will clear the port openings.

The chasers are expanded to the cutting position by means of a handle provided for that purpose after the tap has entered the valve body through one of the port openings.

The two threads are tapped with the same chasers in one chucking. The tap is suitable for valves with either parallel or angle seats. Valves with angle seats require a fixture of the trunnion type with stops for bringing the valve seat ring openings in line with the tap.

Brauer Flow Control Valve

THE new Brauer flow control valve, designed for an all-purpose valve, is announced by Brauer Machine & Supply Company of Oklahoma City. It can be used on discharge lines of slush pumps, permitting the operation of either one or both pumps at the same time. It will also enable users to compound the pumps when necessary.

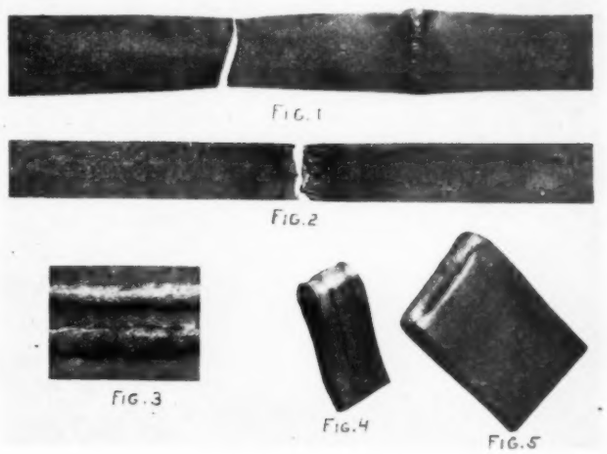


This flow valve can be used on either a one- or two-standpipe hook-up, the fluid flow being handled in any direction desired. Both standpipes can be closed at the same time.

Full particulars on the Brauer flow control valve can be secured from the Brauer Machine & Supply Co., at Oklahoma City.

Electrode for Arc-Welding Stainless Steel

A NEW electrode for the arc-welding of stainless steel has been developed by the Lincoln research laboratories and is now in manufacture by The Lincoln Electric Company, Cleveland, Ohio. The electrode will be known to the trade as the new, improved "Stainweld A."



"Stainweld A" is an extruded electrode used with usual polarity of welding current reversed. The coating of this electrode contains no carbon. Physical and chemical tests prove the high tensile strength, ductility and resistance to corrosion claimed for welds produced with this new electrode, the manufacturers state. The accompanying photograph in Fig. 1 shows a tension test sample with weld ground finish flush with the plate metal on one side only which broke in the plate at considerable distance from the weld under tension of 96,000 pounds per square inch. When the cross-sectional area of the weld metal on another test coupon was reduced below that of the plate metal in order to obtain break in the weld it required pull of 96,800 pounds per square inch to break the weld as shown in Fig. 2.

The result of a comparative test to determine the effects of corrosion is illustrated in Fig. 3. Bend tests are shown in Figures 4 and 5.

Calmec Ball-Guided Valve

THE Calmec Manufacturing Company, Ltd., 5817 Riverside Drive, Los Angeles, Calif., announces a new valve for reciprocating pumps used in oil well drilling, pipe line, refinery and for general use. It is of the conventional ball-and-seat type.

The Calmec ball-guided valve deflects the fluid, causing less friction, and has a tendency to prevent valve lifting higher than necessary to discharge the fluid. It also eliminates part of the pressure, insuring shock-free operation at the highest speed at which the fluid will flow into the pump without excessive slip.

Also, it is claimed that the valve decreases the high pressure between suction and discharge valves, resulting in less piston and valve slip, with a corresponding increase in pump efficiency.

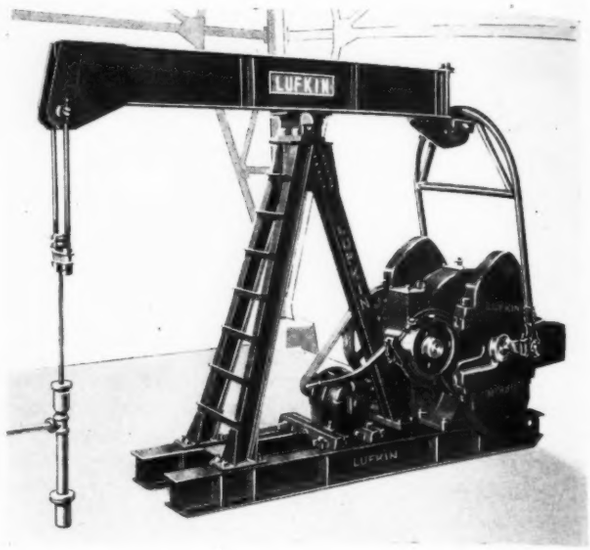
Lufkin Twin-Crank Pumping Unit Assembly

THE Lufkin Foundry and Machine Company, Lufkin, Texas, announces the manufacture of its Twin-Crank Pumping Unit assembly, which, complete in every detail from prime mover to polished rod hanger, is mounted upon a rigid, reinforced, structural steel bed plate, and fulfills a need for a portable, economically installed and operated unit for wells of medium depth.

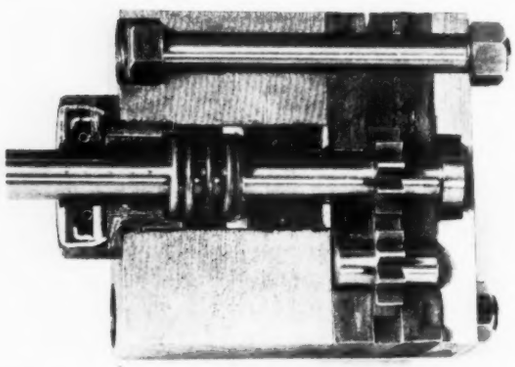
The new Lufkin Unit is equipped with Sykes Herringbone continuous tooth gearing (oil bath lubrication) having Hyatt equipped pinion shaft and bronze gear bearings. Equipped with Lufkin-Trout counter-balanced cranks on either side of the gear box all "winding" or "weaving" is eliminated. The Twin-Pitman is of reinforced bent-pipe construction equipped with a Universal "ball-joint" connection to the beam which allows for misalignment and insures equal pull for each crank. Trout Universal dustproof, oil bath (box on pin) Pitman connections are regular equipment with the new unit. An adjustable stroke length, the maximum of which is 42 inches, and a stroke speed of from 15 to 28 strokes per minute is obtainable.

The new Lufkin Twin-Crank unit is designed to operate with either electric motor or gas engine drive and is furnished complete with belt and motor house.

Complete details concerning the new Lufkin Twin-Crank Unit assembly will be gladly furnished upon request, addressed to the Lufkin Foundry & Machine Company, Lufkin, Texas.



Nitralloy Solid Steel Pump



THE Northern Pump Company, Minneapolis, Minn., is manufacturing a solid steel pump, in which all of the working parts coming in contact with the liquid are made of Nitralloy steel, a new alloy steel, invented by Dr. Adolf Fry of the Krupp research laboratories of Essen, Germany. The pump is so constructed that centrifugal force throws all solids away from the inner meshing point of the pumping elements. All shafts thrust occasioned from driving on the coupling, misalignment or any outside source is taken care of by a Nitralloy collar running against hardened surfaces, and this prevents wear on the faces of the pump gears. An outboard gearing is provided so that the pump may be driven by a gear or a belt if desired. All parts are accurately ground, so that no shims or gaskets are required.

Nitralloy steel is said to be almost as hard as diamond, having a measured hardness of 900 to 1100 Brinnel. This material is highly resistant to the action of acids commonly found in fuel oil and other oils.

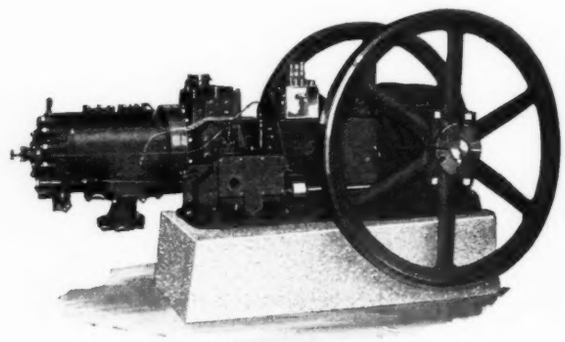
The pump is suitable for fuel oils, lubricating oil, gasoline and other similar oils.

Full details of this new pump may be obtained from the Northern Pump Company.

Reid Single Cylinder Diesel Engine

A FULL Diesel engine of the single cylinder, horizontal type especially designed for oil field service has been built and installed by the Joseph Reid Gas Engine Company, Oil City, Pa. The engine is known as the type DC Diesel Convertible engine, rated at 40 horsepower at 275 r. p. m. It is a solid-injection, two-stroke cycle Diesel which may be converted to a gas engine.

A fuel pump and injector nozzle provide a dependable fuel system which functions efficiently and economically on fuel or furnace oil of the average gravities. The fuel pump operates from a cam on the engine layshaft.



The engine is easily and quickly converted from one fuel to the other. Two men working in the field can effect the change in one hour's time.

Exhaustive tests at the factory and in the field have proved these Reid Type DC Diesel Convertible engines to be entirely practical and economical. The fuel consumption rate on the engine is about .4 pounds per BHP hour, and the gas engine uses 11½ cubic feet of gas per BHP hour.

Reid Bulletin No. 55 gives power curves and detailed specifications.

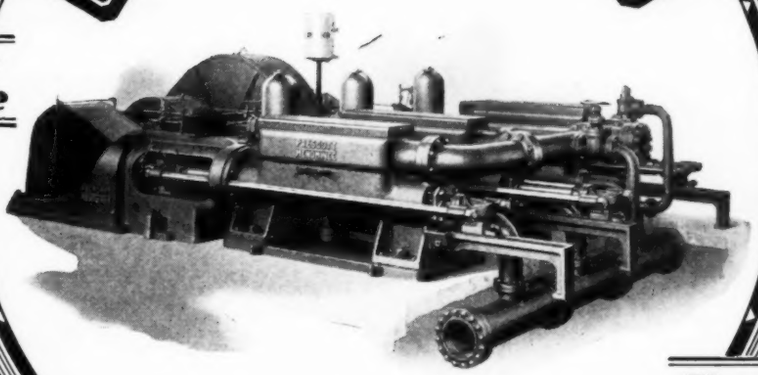
NORTH and SOUTH EAST and WEST

GASOLINE MOVES

via

PRESCOTT

Any Capacity
Any Pressure



Electric Motor,
Diesel, or Gasoline
Engine Drive

We take justifiable pride in the fact that SIXTY-SIX PRESCOTT GASOLINE PIPE LINE PUMPS *have already been sold to major companies. These pumps range in capacity from 7000 to 32,500 barrels per day.*

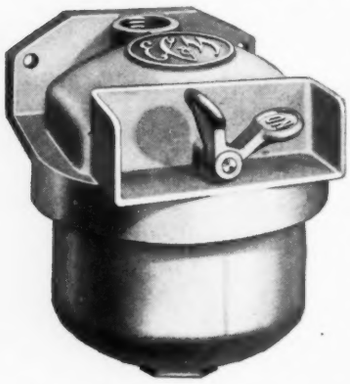
The Prescott Company

Menominee, Michigan — U. S. A.

PRESCOTT·PUMPS·PREDOMINATE

When writing THE PRESCOTT COMPANY *please mention The Petroleum Engineer*

Explosion-Proof Push Button



A NEW explosion-proof Push Button, now being built by The Electric Controller & Manufacturing Company of Cleveland, Ohio, may be used with safety in any highly dusty, corrosive or explosive atmosphere for control circuits of automatic motor starters and for turning lighting circuits on and off.

The enclosing case is made of die cast aluminum, the upper part of which is equipped with two mounting holes. The lower half is the tank which screws on the upper half, and since the vertical length of the threaded overlapping surface is ⅝-inch, the joint is very rugged and tight. The hole for conduit connections is tapped for ¾-inch conduit pipe and is located at the top.

This combination of oil-immersed contact and terminals and a case strong and tight enough to prevent the transmission of any flame to surrounding atmosphere, enables this push button to meet the requirements of an explosion-proof push button.

The contact mechanism of the button is very ruggedly built and is exceedingly simple in design. The base is of insulated material on which are mounted the contacts and terminals. The contacts are of heavy copper bar and designed to provide a wiping action when the circuit is made or broken. A single large compression spring insures ample pressure between contacts.

American Shot Barrel

A SHOT barrel on which the plunger may be recupped by merely pouring shot down the tubing when production weakens is being manufactured by the American Iron & Machine Works Co., Oklahoma City.

The shot poured down the tubing will lead-up the gray iron barrel, filling up any inaccuracies so as to make a smooth, close-sliding fit for the plunger, adjusting its own tightness and insulating the loadstone away from the balls and seats to insure maximum capacity pumping.

If it becomes necessary to pull the plunger out of the barrel after the shot has been poured in, the shot will pass the standing valve into the shot trap in the bottom of the barrel. After rerunning the plunger, more shot is poured in.

The barrels are called and classified as 6, 8 and 10-foot barrels, although they are considerably longer than classified. They are made for either upset or regular tubing.

The manufacturers recommend the 6-foot barrel for wells to the depth of 2400 feet, the 8-foot barrel to 4500 feet and the 10-foot barrel to 6000 and more feet.

BJ Rod Hooks

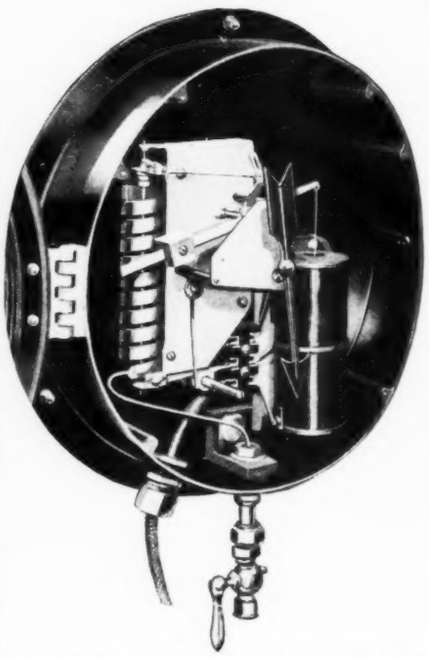
BYRON JACKSON CO. of Los Angeles, Calif., has just placed on the market two new rod hooks, designed particularly for the increased length of strings of sucker rods used today in deeper wells.

The smaller hook, which is designated as the BJ "15," is recommended for a safe load capacity of 15 tons, this weight being the equivalent of a 17,000-foot string of ¾-inch sucker rods complete with couplings; the larger hook is designated as BJ "20" and is recommended for a safe load capacity of 20 tons, being the weight of a 23,000-foot string of ¾-inch sucker rods complete with couplings.

A unique feature of construction of these hooks is the locking arm which extends outward from the bill of the hook and closes automatically when the elevator bail is taken. This locking arm cannot thereafter be unlatched except by the operator and not fully opened until the load is removed.

Descriptive illustrated literature may be obtained by addressing Byron Jackson Co., P. O. Box 1307, Arcade Station, Los Angeles, Calif.

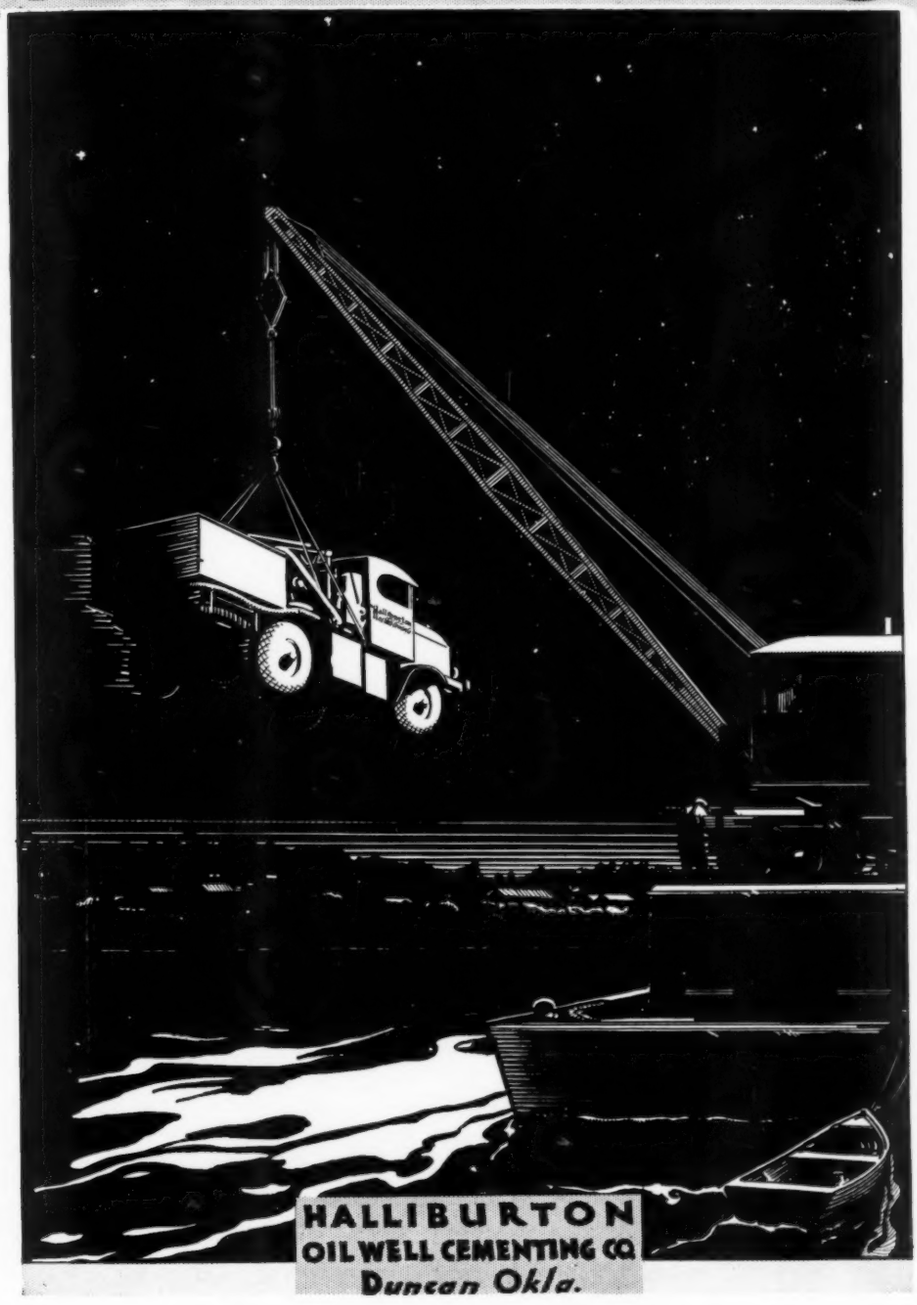
Brown Remote-Type Gauge



THIS instrument operates by means of a tubular helix which opens and closes with pressure changes, this motion causing an armature to rise and fall in an inductance bridge coil. An indicating or recording instrument contains a similar coil armature which follows the movements of the armature in the transmitter. Thus the receiving instrument indicates or records the pressure changes actuating the transmitting instrument.

The transmitting instrument may itself perform the function of an indicating instrument as well as a transmitter by being equipped with a dial and pointer, the latter being directly operated by the movement of the helix through a suitable link motion. By means of this instrument, pressure changes may be transmitted over distances as great as 30 miles and be accurately indicated or recorded by the receiving meter, state the manufacturers, The Brown Instrument Co., Philadelphia, Pa.

HALLIBURTON



"WE'LL Get There Somehow"—how the Halliburton crews have fought to maintain that famous slogan! The storms they have bucked, the roads they have conquered, the conditions they have overcome are all part of oil industry history.

The illustration shows a Halliburton cementing outfit being loaded on a barge on its way to a well in the Gulf of Mexico.

To receive your copy of "The Cementer" regularly as issued, sign and return the form below.

Place me on the list to receive THE CEMENTER as issued » »

NAME..... COMPANY..... ADDRESS.....

When writing HALLIBURTON OIL WELL CEMENTING CO. *please mention The Petroleum Engineer*

W. S. "Buck" Morris, petroleum engineer, Indian Territory Illuminating Oil Co., has been transferred from Bartlesville to Oklahoma City, Okla.

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G. W. "Waldo" Moore has left Tulsa on an extended trip for Byron Jackson Co., in the capacity of sales representative. Mr. Moore is driving through the Rock Mountain section and then to Canada, where he will be stationed during the summer months. His friends can communicate with him through the National Supply Co., at Calgary.

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Edward Steen, drilling contractor, has moved from Wilson, Oklahoma, to 901 North Moore Street, Tyler, Texas.

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R. J. S. Piggott, chief of the mechanical engineering section of the Gulf Research Laboratories, Pittsburgh, Pa., spent some time in the Mid-Continent fields recently. While here he attended the Meter Course held at the University of Oklahoma, Norman.

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U. de B. Daly

U. de B. Daly has announced his resignation as president of the Shell Petroleum Corporation and as director and member of the executive committee of the Shell Union Corporation. Mr. Daly's brief statement contained no announcement of future plans.

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Ernie Richards, of National Tank Company, has been in East Texas so long that he is considered a native.

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C. L. McMahon, president, C. L. McMahon, Inc., is now commuting between Henderson, Texas, where he has drilled in two large wells, and his home in Tulsa, Okla.

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A. C. Jamison, assistant division superintendent, Arkansas Fuel Oil Co., has moved from Shreveport, La., to the Palace Hotel, Longview, Texas, so as to be closer to the company's holdings in the new East Texas fields.

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M. F. Waters, of Hanlon-Waters, Inc., Tulsa, Okla., visited home long enough to get a clean shirt and then returned to East Texas.

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N. R. Putman, Tulsa representative of Reading Iron Company, has just returned from an eastern trip during which he visited his company's New York office.

W. S. Morris

A. O. Behling, superintendent of the Humble Oil & Refining Company's division offices at Corsicana, Texas, has been transferred to Tyler, Texas, as a result of the activity in the new East Texas oil fields. The division office for this territory will be located at Tyler.

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George B. Morris, president of Bradford Motor Works, is making a tour of the Mid-Continent oil fields, accompanied by sales representatives.

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C. E. McCarthy, superintendent of construction, Moody-Seagraves Corporation, is now located at Tyler, Texas. He was formerly at Houston.

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Henry Waters, formerly chief scout of the Sinclair Crude Oil Purchasing Company, and who continued in the same capacity with the Stanolind Crude Oil Purchasing Company, has been promoted to executive assistant to the president of the company.

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Bart Meyers, manager of the Tropical Oil Co., took time out to shoot a little golf at the Tulsa Country Club when this picture was snapped. He is in the United States for a vacation, and will soon return to his headquarters at Colombia, S. A.

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Bart Meyers

T. H. Mahler, formerly field engineer for the Shell Oil Company at Coalinga, Calif., is now chief engineer for the Kettleman North Dome Association. He is still located at Coalinga.

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K. S. Richards, of Tulsa, is on a trip to the headquarters of his company, Atlas-Imperial Diesel Engine Co., Oakland, Calif., where he will superintend the preparation of a shipment of engines to Persia.

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A. C. Jamison

A. C. Rubel, formerly assistant manager of field operations for the Union Oil Co., has been promoted to the position of manager of field operations, succeeding F. F. Hill, who was appointed director of production.

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George Pennington has been appointed vice-president and general manager of the pump division of Victor Equipment Co., which was formed by a merger of the Victor Welding Equipment Co. and the Kimball-Krogh Pump Co. Mr. Pennington will make his headquarters in Los Angeles.

Contributions

to the PETROLEUM REFINING INDUSTRY:

"Pressure" Cracking Without Reaction Chambers or Soaking Drums

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Combined Topping and Cracking

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Combined "Pressure" and "Vapor Phase" Cracking

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When writing THE WINKLER-KOCH ENGINEERING COMPANY *please mention The Petroleum Engineer*

H. B. Ward

H. B. Ward, of the H. F. Wilcox Oil & Gas Company, has been elected president of the Purchasing Agents' Association of Tulsa. He succeeds W. R. Brown, Mid-Kansas Oil & Gas Company.

W. J. Crites, superintendent of water department, Phillips Petroleum Company, has been transferred from Oklahoma City to Bartlesville, Okla.

C. H. Otto, formerly chief gauger for the Sinclair Texas Pipe Line Company at Wharton, Texas, is now district gauger for the company in the East Texas district. He is located at Henderson, Texas.

G. H. Garcelon has been made manager of the control engineering department of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. Mr. Garcelon succeeds J. H. Belknap, who has been transferred to the engineering division of the Pittsburgh district office.

George P. Torrence has been made a director of the Link-Belt Company. Mr. Torrence, a graduate of Purdue University, joined the Link-Belt organization in 1911. In 1915 he was made manager of general sales at the company's Pershing Road plant at Chicago. He was made vice-president in 1928, in charge of the Indianapolis plant.

George P. Torrence

Dick Battle of Hanlon-Waters, Inc., Tulsa, Okla., has returned to East Texas after being confined to his home in Tulsa by illness.

T. J. Twoney, formerly superintendent of the gas department, Gulf Refining Company, Port Arthur, Texas, is now superintendent of the Cincinnati refinery of the Gulf Refining Company.

E. L. Decker of Martin-Decker Corporation made a recent tour of Mid-Continent fields, having made the trip from Los Angeles to Oklahoma City by plane.

R. W. McBurney, sales manager of Leahy-McNeely Co., Ltd., Long Beach, Calif., manufacturers of Lemco rotary mud screens, spent considerable time in the Mid-Continent early in the month. With him was J. E. Leahy, chief engineer of the company.

A. G. Loomis, in charge of the chemical section of the Gulf Research Laboratories at Pittsburgh, Pa., has made an inspection tour of the Mid-Continent oil region.

C. Allen Fulmer of Tulsa, Okla., oil industry manager for Ampco Metals, Inc., while still retaining his connection with Ampco Metals, has become district manager of Oklahoma-Kansas for the General Alloys Company of Boston.

L. E. Lewis, superintendent of the Van (Texas) district for the Pure Oil Company, has recovered from a recent major operation.

Fred Forster, tool pusher for Mandeville and Thompson, drilling contractors, has been transferred from Oklahoma City to 1402 East Earl Street, Tyler, Texas.

G. I. Keniston, superintendent, Standard Oil Co. of California, Taft, Calif., has moved to Coalinga, Calif., where he is superintendent of the Kettleman Hills Division.

Leo H. Towers, engineer, with the Great Lakes Pipe Line Company, is now located at Faribault, Minn., where a station is being built on the company's gasoline line from the Mid-Continent.

George L. Ratcliff, president and general manager of California Talc Company, was a Houston (Texas) visitor last month.

V. K. Veness, previously repressure plant superintendent, Humble Oil & Refining Company, at Sugarland, Texas, is now gasoline plant foreman for the company at Neches, Texas.

Carl D. Anderson, formerly superintendent of the Bristow compressor station for Cities Service Gas Company, is now superintendent of the Newkirk (Okla.) station.

W. L. Plemons, drilling superintendent, F. B. Paine Drilling Company, has moved to Longview, Texas. He was previously at Electra, Texas.

H. E. Zoller, field engineer, Shell Petroleum Company, Tulsa, Okla., has been transferred to the Comar Oil Company, a Shell subsidiary, at Marland, Okla.

Byron M. Landis, well known to many oil men both in California and the Mid-Continent, has assumed his duties as sales representative for Byron Jackson Co., with headquarters at Oklahoma City.

J. M. Sterritt, superintendent Minnehoma Oil & Gas Company, has been transferred from St. Louis, Okla., to Oklahoma City, Okla.

Skeet Davenport, C. E. Reynolds Drilling Company, has moved from Oklahoma City to Abilene, Texas.

Skeet Davenport

H. P. Taubman, president Taubman Supply Company, visited Houston and San Antonio, Texas, during April.

Hoyle Jones, president Superior Tube Company, Tulsa, Okla., was a Texas visitor during April.

PICTORIAL PETROLEUM

Monthly Rotogravure Feature of The Petroleum Engineer

May 1931

Stabilizers of Signal Gasoline Company's old plant at Rita Santa, Texas.

Above left—W. C. Thomas, manager of the Development and Production Department; above center—L. A. Bell, assistant to the manager of Development and Production Department; above right—P. W. Brower, assistant to the manager of Development and Production Department; below—O. H. Eichelberger, district superintendent, Lockport, Louisiana, all with Vacuum Oil Company.

I. W. Alcorn, head of Engineering Research and Development Department of Smith Separator Company, Tulsa, Oklahoma.

This picture was taken at the Los Angeles airport just as John R. Dallerup, vice president and foreign representative of the Reed Roller Bit Company was about to take off for San Francisco on the first leg of his trip around the world in the interests of his company. Left to right, the picture shows W. R. "Frosty" Martin, president of the Martin-Decker Corporation, in whose airplane the trip was made; Mrs. John R. Dallerup; John R. Dallerup; Mrs. E. L. Decker; E. L. Decker, vice president of the Martin-Decker Corporation, and small daughter; Mrs. Harvey Martin; Harvey Martin, pilot; and Mrs. W. R. Martin.

Left to right—T. J. Flanagan, A. V. Simonson and M. J. Flanagan, all with Gaso Pump & Burner Mfg. Co., Mr. Simonson being the foreign representative.

F. R. McCarthy, superintendent, Panhandle Eastern Pipeline Company, Kansas City, Mo.

M. J. Miller, engineer for Panhandle Eastern Pipeline Company, Kansas City, Mo.

John E. Grimmett, pilot for the Great Lakes Pipe Line Company with the company's Travelair cabin monoplane. This plane was used in making a complete aerial survey of the Great Lakes line, and now transports officials of the company on regular tours of inspection.

Right-of-way cut in South Louisiana for the United Gas Corporation's 10-inch line.

Scene on the Uinta Pipe Line Company's gas line from Rock Springs, Wyo., to Salt Lake City, showing improvised railway which hauled men, equipment and supplies to the line.

Some Canadian Operating Men

M. E. Keenan, district manager for Oil Well Supply Company at Calgary, Alberta (left) and Bob Cameron, superintendent Mercury Oils Ltd., Turner Valley.

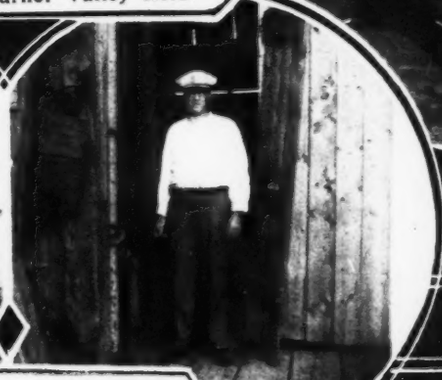
For the photgraphs shown on this page we are thankful to Mr. M. E. Keenan, manager for the Oil Well Supply Company at Calgary, Alberta, Canada. Mr. Keenan has been affiliated with Oil Well Supply Company for many years and is well known in all Canadian fields.

R. L. Cook, president and manager of Rayco Oils Ltd. and superintendent of Ribstone Oils Ltd. Mr. Cook discovered the Ribstone field.

A. W. Dingman, discoverer of the Turner Valley field.

Left to right—Bob Gray, warehouseman; T. Hetherington, warehouseman; F. W. Shelton, field superintendent; and Col. Pryce-Jones, all with Calmont Oils Limited and well known in the Turner Valley field.

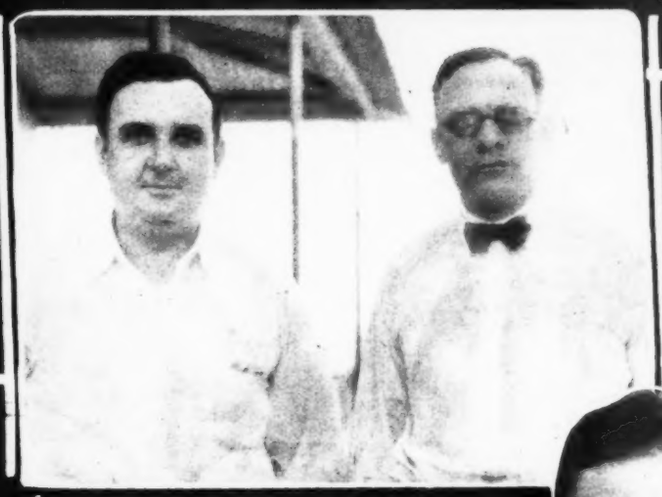
C. E. Snyder, drilling contractor, Turner Valley.



J. C. (Curly) Cairns, Sioux City Oils Ltd. Turner Valley

Left—R. J. Widney, field superintendent, New McDougal Segur & Widney Oils Ltd. Right—R. L. Stephenson, general manager, Peninsular Petroleums Ltd., Wainwright, Alberta.

D. W. Harris, vice president in charge of production for Arkansas Natural Gas Corporation, Shreveport, La.

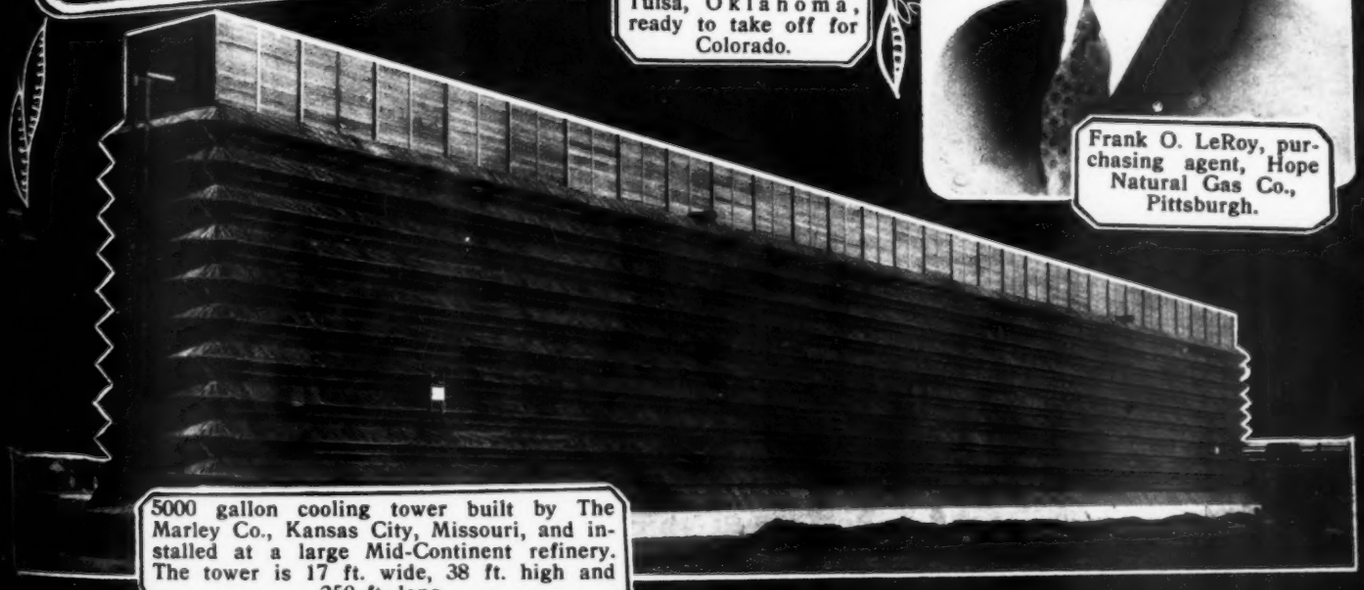


Walter Trout (left) of Lufkin Foundry & Machine Co., and Howard Auerswald, assistant general superintendent, Gypsy Oil Co., Tulsa, Oklahoma.

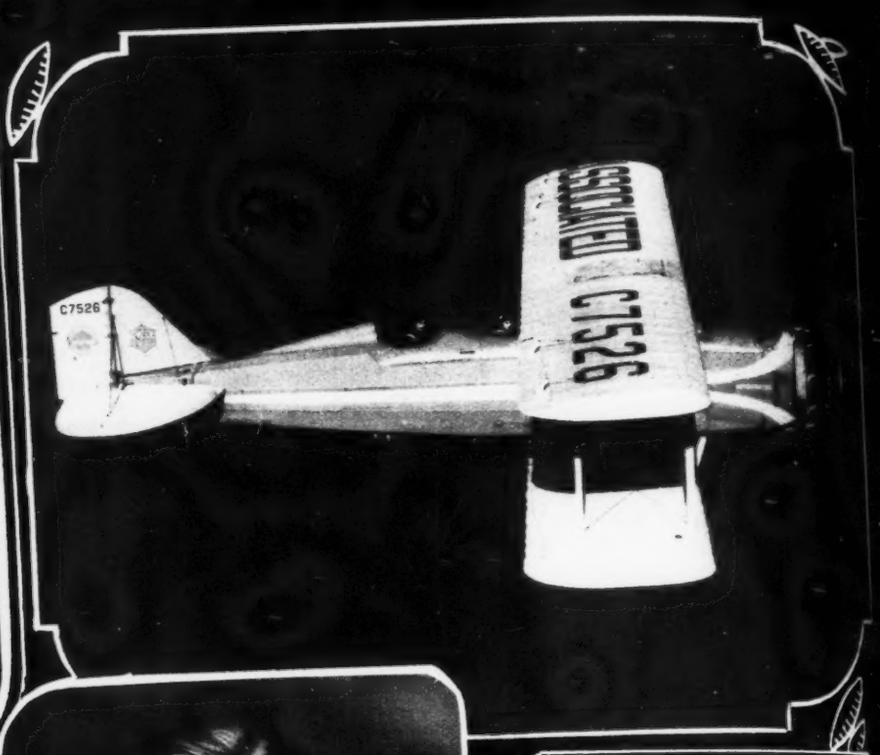
K. B. Nowels, chief petroleum engineer for Forest Oil Corp., Bradford, Pa.

A. M. Horrall, president, Southwestern Construction Corp., pipeline contractors, Tulsa, Oklahoma, ready to take off for Colorado.

Frank O. LeRoy, purchasing agent, Hope Natural Gas Co., Pittsburgh.

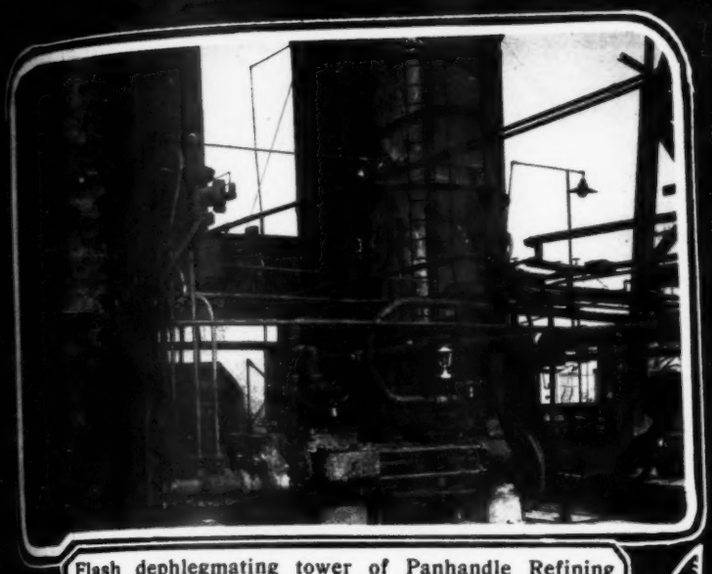


5000 gallon cooling tower built by The Marley Co., Kansas City, Missouri, and installed at a large Mid-Continent refinery. The tower is 17 ft. wide, 38 ft. high and 250 ft. long.



Above—Associated Oil Company's plane in flight over San Francisco Bay. The three photographs of individuals on this page show officials of the Lion Oil & Refining Co., El Dorado, Arkansas. Top, left—T. H. Barton, president; left—M. E. Wilson, vice president; and, below—R. E. Meinert, purchasing agent.

Cooling tower erected by J. F. Pritchard & Co., Tulsa, Oklahoma for Phillips Petroleum Company at Oklahoma City.



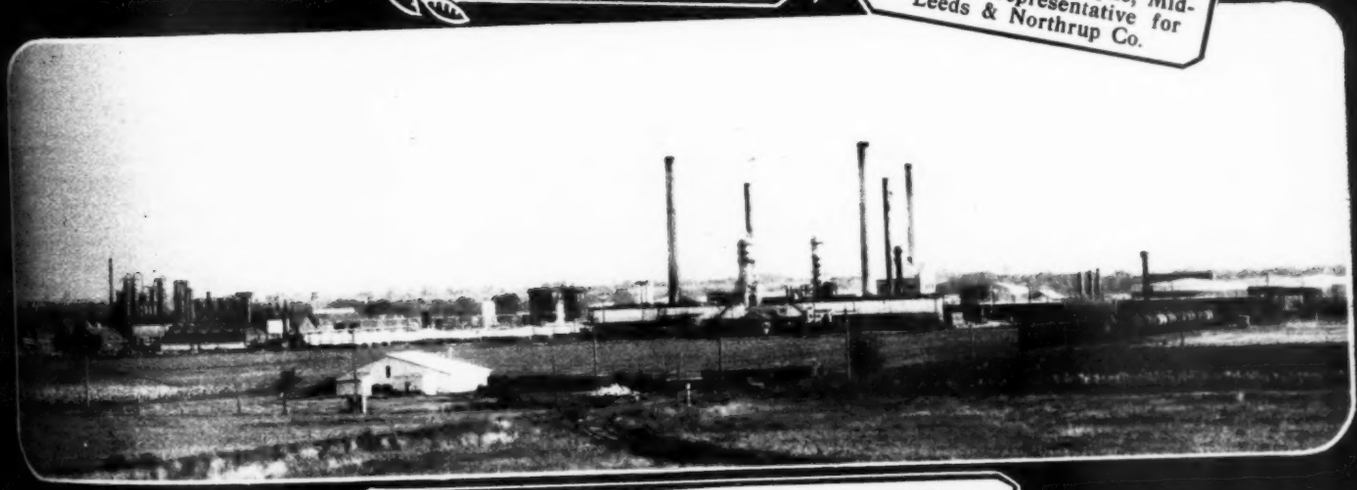
Flash dephlegmating tower of Panhandle Refining Company, Wichita Falls, Texas. This controls steam to hot oil pump operating at 500° F. and handling 1500 lbs. per day. The liquid level controller shown was manufactured by C. J. Tagliabue Mfg. Co.

W. H. McCalif, superintendent Sugar Creek Gasoline plant, United Gas Public Service Co., Sugar Creek, La., and bird dogs owned by Mr. McCalif.

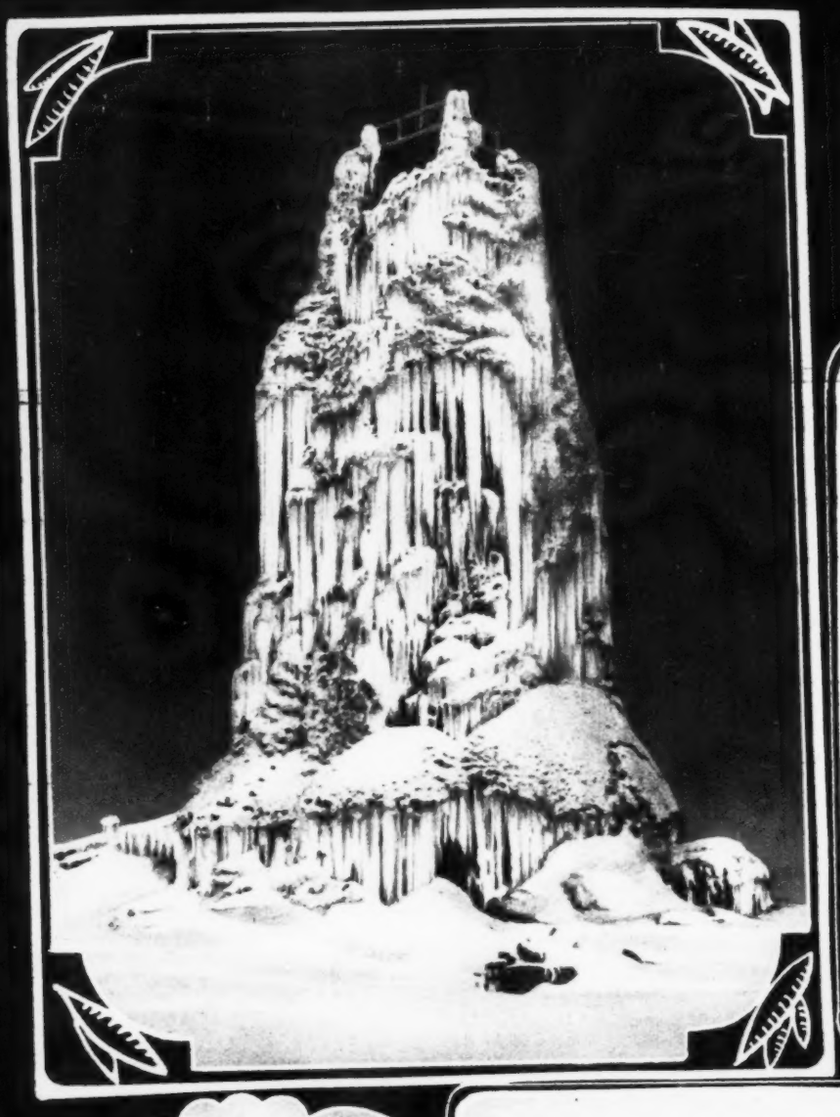
Luther G. Thompson, superintendent gasoline plants, Big Lake Oil Company, Texon, Texas.

A. M. Hovlid, refinery superintendent for the Continental Oil Company at Glenrock, Wyo.

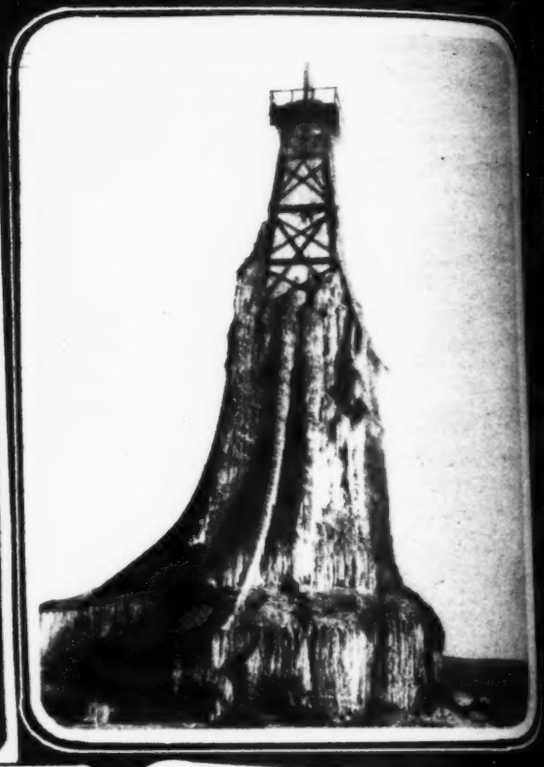
H. F. Richardson (left) chief refinery engineer, Gulf States Corp., Oklahoma City, Oklahoma, and B. F. Koepke, Mid-Continent representative for Leeds & Northrup Co.

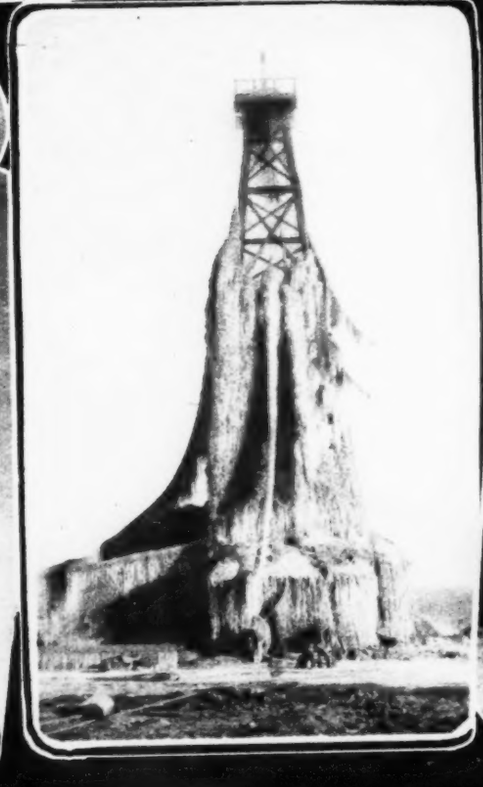


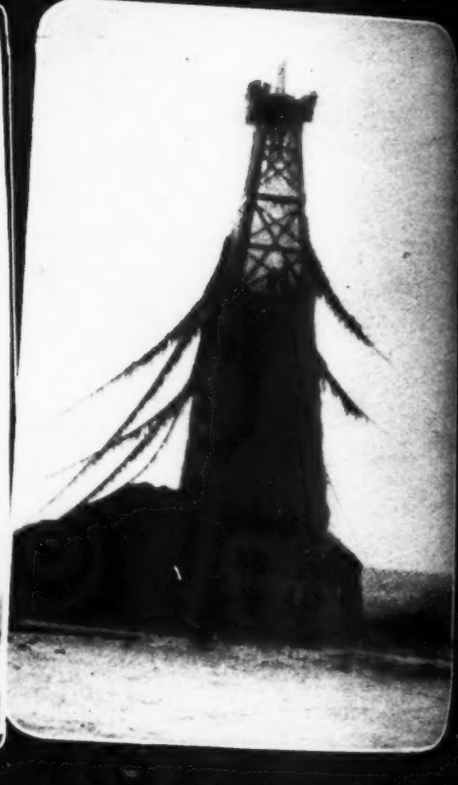
Plant of White Eagle Refining Company, Augusta, Kansas.



Such widespread interest having been manifested in the picture of the ice-encased derrick used as the front cover of our December, 1930, issue, we are, on this page, presenting additional views of the same well (Eagle Butte Oil Company Ltd's. No. 1) in the Cypress Hills of Southern Alberta, Canada. These pictures are especially interesting since they show the well at various stages in the melting of the ice.







Left—R. J. Brennan, vice president and general manager of the Forest Oil Corporation, and (right) Forest D. Dorn, president of the same company, whose headquarters are in Bradford, Pa.

Wesley W. Moore, petroleum engineer for The Texas Production Company at Denver, Colo.

J. M. Shugert, superintendent, Texas Pacific Coal & Oil Co., Santa Maria, Calif.

A. G. Finch, field superintendent, Argo Oil Co., Pilot Butte field, Morton, Wyo.

J. T. Rankin, Denver, Colo., Western purchasing agent for The Texas Company.

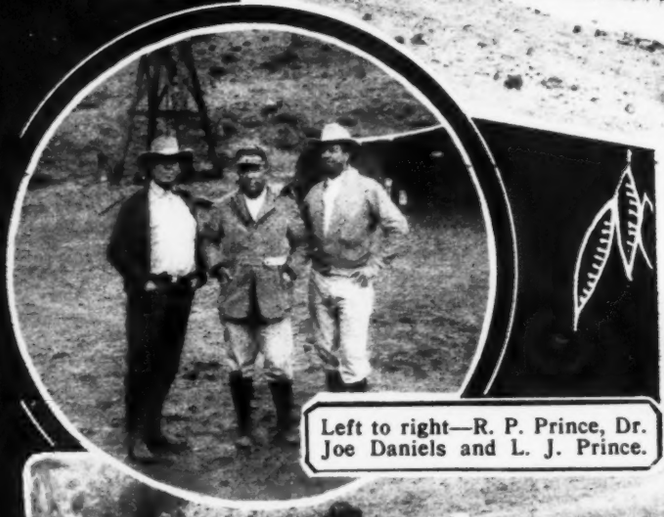
O. Weaver, superintendent gas department, Barnsdall Oil Co. of California, Los Angeles.

L. G. Kinchelor, superintendent main lines, Hope Natural Gas Co. and affiliated interests, whose home is in Clarksburg, West Virginia.

E. E. Young, district superintendent of repressuring department, South Penn Oil Co., Middlebourne, W. Va.

Prince Brothers Annual Deer Hunt 90 Miles north of Silver City New Mexico 1930 Season

Above—J. W. Strickland, drilling superintendent for the Carter Oil Company. Left—The picturesque location of hunting headquarters, ninety miles north of Silver City, New Mexico.



Left to right—R. P. Prince, Dr. Joe Daniels and L. J. Prince.

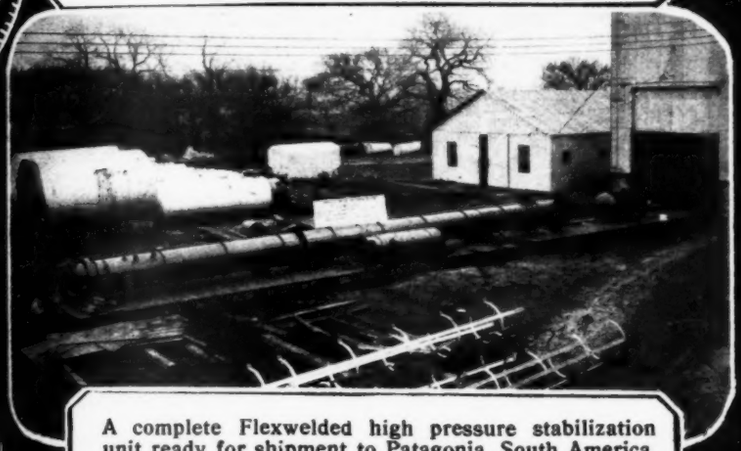
Group picture taken at Mimbres Ranger station. Left to right—Mose Bond of Tibbett & Bond Drilling Co.; Ed Daly of Moran & Daly Drilling Co.; Lon Cron of J. E. Mabee Drilling Company; L. J. Prince of Prince Bros. Drilling Company; Earl Clayton, drilling contractor, Wichita Falls, Texas; Mike Myracle of American Iron & Machine Works Co.; John Cailloux, president of the same company; and R. V. Nickols of Temple, Texas.

H. A. "Dutch" Schaeffer (extreme right) of Hughes Tool Company is shown supervising the unloading of a deer he had bagged in that day's hunt.

Group taken in Silver City, New Mexico. Left to right—Allen Huckleberry, drilling contractor and producer; Ed Daly, contractor; Mike Myracle, American Iron & Machine Works Co.; Earl Clayton, Wichita Falls, Texas, drilling contractor; Ed Moran, Tulsa, Oklahoma, contractor; Dr. J. H. Kemp, Wichita Falls oil producer; R. P. Prince, Electra, Texas, contractor; Dr. Joe Daniels, medical director Great Southern Life Insurance Co., Houston, Texas; John Cailloux, American Iron & Machine Works Co.; and Judge Luther Bohannon, Oklahoma City attorney.

Imperial Oil Company refinery at Imperoyal, Nova Scotia. Halifax lies directly across the river.

J. D. Goulett, construction engineer, East Texas Refining Company, Longview, Tex.



A complete Flexwelded high pressure stabilization unit ready for shipment to Patagonia, South America, for the Cia Ferrocarrilera Petroleo. This equipment was manufactured by American Tank and Equipment Corp., Oklahoma City, Okla., a subsidiary of Black, Sivalls & Bryson, Inc.

W. M. Carney, chief chemist, Lion Oil Refining Co., El Dorado, Ark.

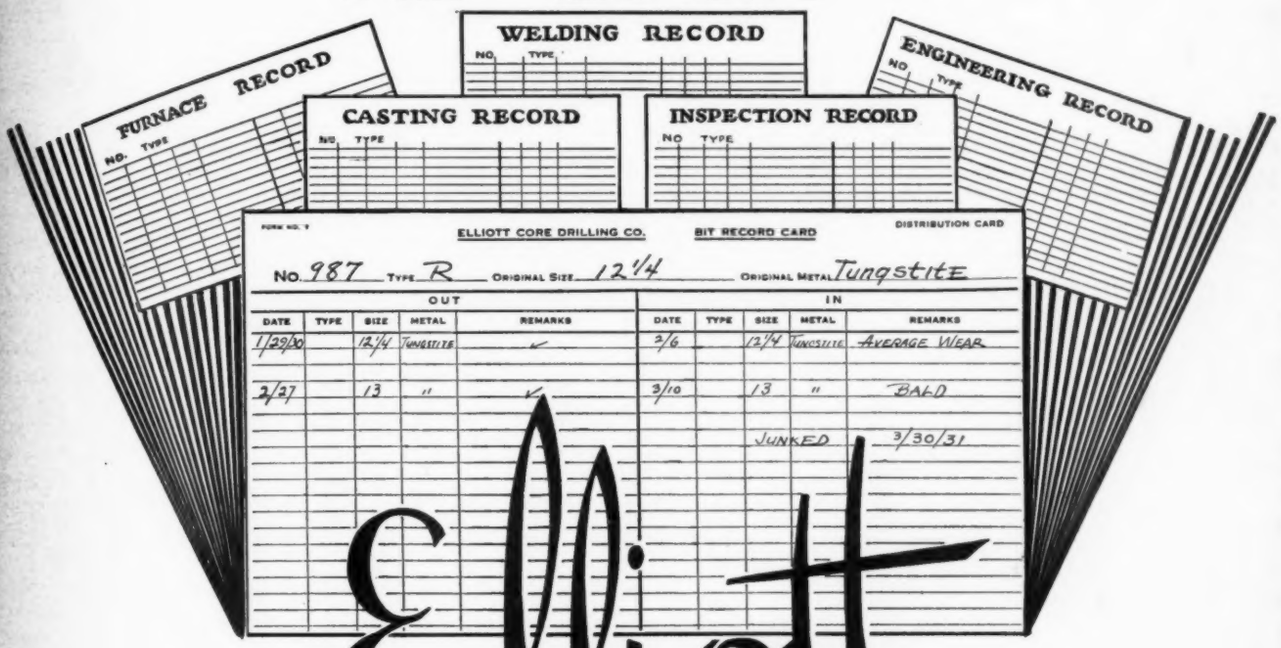
J. L. Le Bleu, refinery superintendent, Lion Oil Refining Company, El Dorado, Ark.

John J. Thomas II, vice president of the East Texas Refining Company, also vice president of Burford Oil Co., Dallas, Tex.

A. J. Rosenlieb, district superintendent for The Ohio Oil Company, Venice, Calif.

Cities Service Gas Co.'s 12-inch acetylene-welded line from Ottawa, Kansas, to Sedalia, Missouri. This view shows a rocky stretch of country near Warrensburg, Missouri. Line was built by Henry L. Lemons, Inc.

—each card— important protection *for users*



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Design and Operation of an

A. C. Diesel Electric Rig

By H. F. SHEPHERD*

LAST year, after geophysical work and some drilling had established the existence of a number of domes under water and marsh land in Southern Louisiana, certain major operating companies turned their attention to the power situation.

The Texas Company assigned L. K. Laney, consulting engineer, to make a special study of the situation with R. C. Stewart, manager of the East Texas and Louisiana Division.

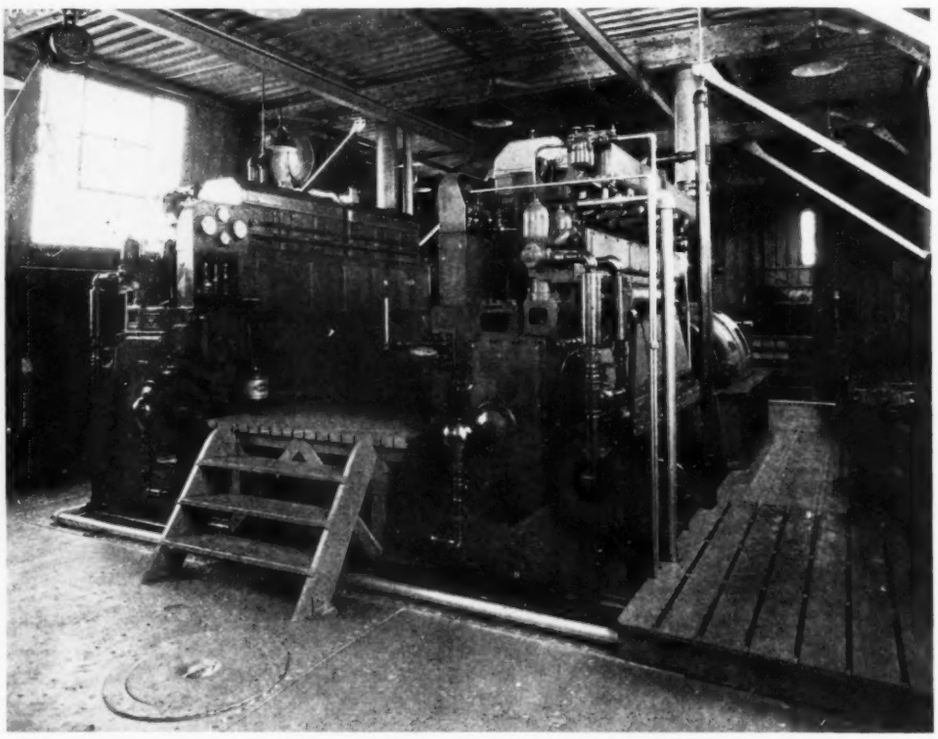
Southern Louisiana had been occupied up to this time only by the trapper. It is without passageways other than the bayous and canals. Thus it offers power, transportation and camping problems unique in the history of North American oil field development.

The waterways are so numerous that, from an airplane the country appears to be mostly inundated. Freighting of rig equipment, tubing, mud and general supplies by barge is ideal on the upper streams. Production also is barged out. Canals may be dredged from the main water courses to land locations at the rate of a mile per week with equipment now in use.

On the bay and lower bayou locations, however, every means of avoiding the necessity of regular barge movements must be avoided. Soundings vary greatly with the tides, which are not astronomical so much as meteorological, changing with the prevailing winds. Seasonally rather than diurnally, the tides reduce the water level so much that even shallow draught floating equipment finds shoal water. At other times, high, rough water in the bays and strong head winds make outward movements of loaded barges hazardous if not impossible.

These factors led to the decision to design and build floating Diesel electric power plants to supply electric energy to the rigs. A steel barge designed by Mr. Laney carries the power plant. This barge is fireproof, roomy and clean. It provides quarters for two men and a small workshop and is of decidedly good appearance. The Texas Company's faith in the project is reflected in the provision of this fine piece of floating equipment.

The engines chosen have proven highly successful at sea, driving D. C. ships' auxiliaries and Ward Leonard sets for main propulsion motors of tankers. Also there are many applications in A. C. power plants on land where engines are required to handle industrial loads quite as exacting of them as drilling.



The pair of Cooper-Bessemer 240-horsepower Diesel engines direct-driving 175-kilowatt electric generators in the barge "Energy."

These engines are designed for salt water circulation and fitted with pumps and oil coolers suitable for tropical waters.

When the Texas Company's power barge was being designed, one well had been drilled in California with the recent adoption of Ward Leonard control to Diesel-driven D. C. generators, while a great many wells had been drilled with A. C. motors.

The Texas Company owned some A. C. motor equipment which could be put to use. There was the prospect of using the plant for swabbing or pumping with conventional A. C. pumping motors driving standard rigs until permanent equipment could be decided upon and installed. Use of the power barge as an emergency power plant at any of the tide water operations was also considered, as well as the possibility of transmitting energy over some distance by the use of transformers at barge and location.

The simplicity of wiring of the A. C. rig was helpful, only three leads being required between barge and rig.

Above all, the fact that the A. C. power plant could supply power as needed to two variable speed motors with either or both engines was considered most favorable.

*Assistant Chief Engineer, The Cooper-Bessemer Corporation.

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Here at last is a perfected automatic device that definitely controls the measurement of fluid between high and low limits. Maximum and minimum differential limits may be easily set, so that the new Neilan Differential Limit Controller will operate alertly on a meter run hook-up and cut in such additional meters as may be required. As soon as the load drops again the additional meters are automatically cut out. Furthermore this Neilan Controller may be used to close a valve in a transmission pipe line in the event of a break in the line. It may also be used to supply additional fluid make-up during peak load periods.

A similar Neilan Pressure Limit Controller may be used for controlling pressure limits. It will accurately maintain discharge pressure limits on steam-driven compressor units. It automatically cuts in additional pumps or turbines when the line pressure drops to a set pressure, and cuts them out again when they are no longer needed.

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There was some doubt as to whether the A. C. motors would require excessive power for their starting current. Also trouble in maintaining parallel operation of the two A. C. generators under the broad and sudden load changes was predicted.

These doubts were not shared by the designer of the power barge nor by the builders of its machinery. In actual service the automatic time delay controls of the A. C. motors function to keep the starting current within

The Texas Company's barge "Energy" alongside one of the operations for which it is furnishing power.

the capacity of one engine with sufficient reserve to permit starting the mud pump motor after the drilling motor is in operation. In other words, it is quite possible to drill with one engine having a rating of 250 horsepower and a useful peak capacity of 300 horsepower, and even to spud for freeing the bit of gumbo with the mud pump operating.

At Leesville No. 2 the conductor and the first string of casing were set with one engine for no other reason than to see if it could be done.

The long string of casing was set, for the sake of certainty, with both engines running in parallel, although one engine might have handled it.

Only when the plug reached bottom in the Baker shoe when cementing the 9⅝-inch string was the plant really tested. When the pump stalled, both ammeters registered against their stops for the moment.

At no time was there any difficulty in paralleling or from unequal division of the fluctuating load.

An abbreviated summary of operations is given in Table 1. A time study of the operations of pulling drill pipe and running in is recorded in Table 2.

It will be noted that the maximum demand is 310 amperes, which equals approximately 310 horsepower. This occurred when lifting the eleventh fourble on low-high. The twenty-four seconds for the twenty-eighth fourble in high-high with only 250 amperes demand is also quite good.

The pulling time could be much reduced by the use of a larger motor, the present motor being rated 125 horsepower. It is doubtful, however, if the overall gain would justify the added strain on equipment.

The average fuel consumption for the plant should be, in Southern Louisiana digging, about 4 barrels per day. It could scarcely exceed eight barrels per average day in any location. The water cost is practically nil anywhere. On water locations salt water is used for cooling, while inland a radiator of ample capacity is used.

It is far too early yet to predict maintenance costs.

A thorough inspection of engines at the end of operations on Leesville No. 2 shows them as good as new.

A considerable saving in the cost of moving and rigging up is realized when using Diesel power, particularly when the floating type of power plant is used.

TABLE 1.

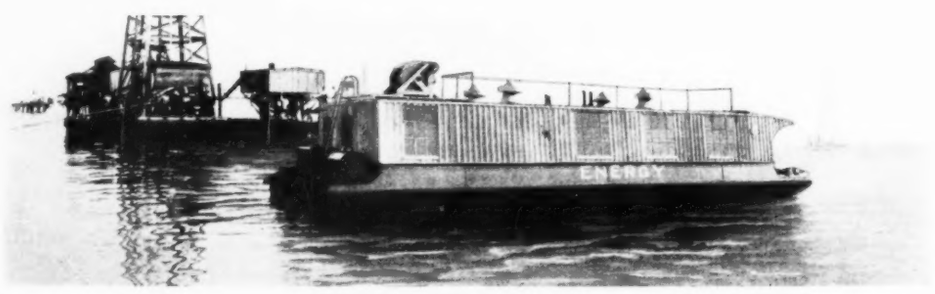
LEESVILLE No. 2

Summary of Operations

Drillers: J. H. Bentley, C. B. Carrothers

Split Tours at Noon	T. D. at End of Tour—Ft.	Remarks
24-A	71	Rat hole and drill.
25-A	176	Set 120 feet, 20 inches; unload mud.
29-A	1131	Setting, 12½ inches; pull, 20 inches. Load and unload barge.
30-M	1138	Set B. O. preventer; unload oil and material.
31-M	.....	Waiting for cement to set.
31-A	1258	Drilled 12½-inch plug.
9-A	3040	Unload cement, wash hole, unload 9⅝-inch.
11-M	3028	Set and cement 3000 feet 9⅝-inch; cement, 150 sacks.
14-M	.....	Unload 4½-inch, take off B.O. preventer and master gate. Put on control head.
15-M	.....	Make up 4½-inch in fourbles, change ditch, make up Xmas tree. Overhaul pumps, lay flow lines, etc.
16-A	.....	Drill plug and clean to bottom.
17-M	.....	Set screen and 4½-inch. Set Xmas tree, connect to flow lines.
17-A	.....	Finish connections, anchor.
18-M	.....	Finish connection work and wash until 2 a. m.

M—Morning tour, 12M to 12N.
A—Afternoon tour, 12N to 12M.



The Texas Company's power plant barge "Energy," in which is installed a pair of Diesel engines direct-driving A. C. generators.

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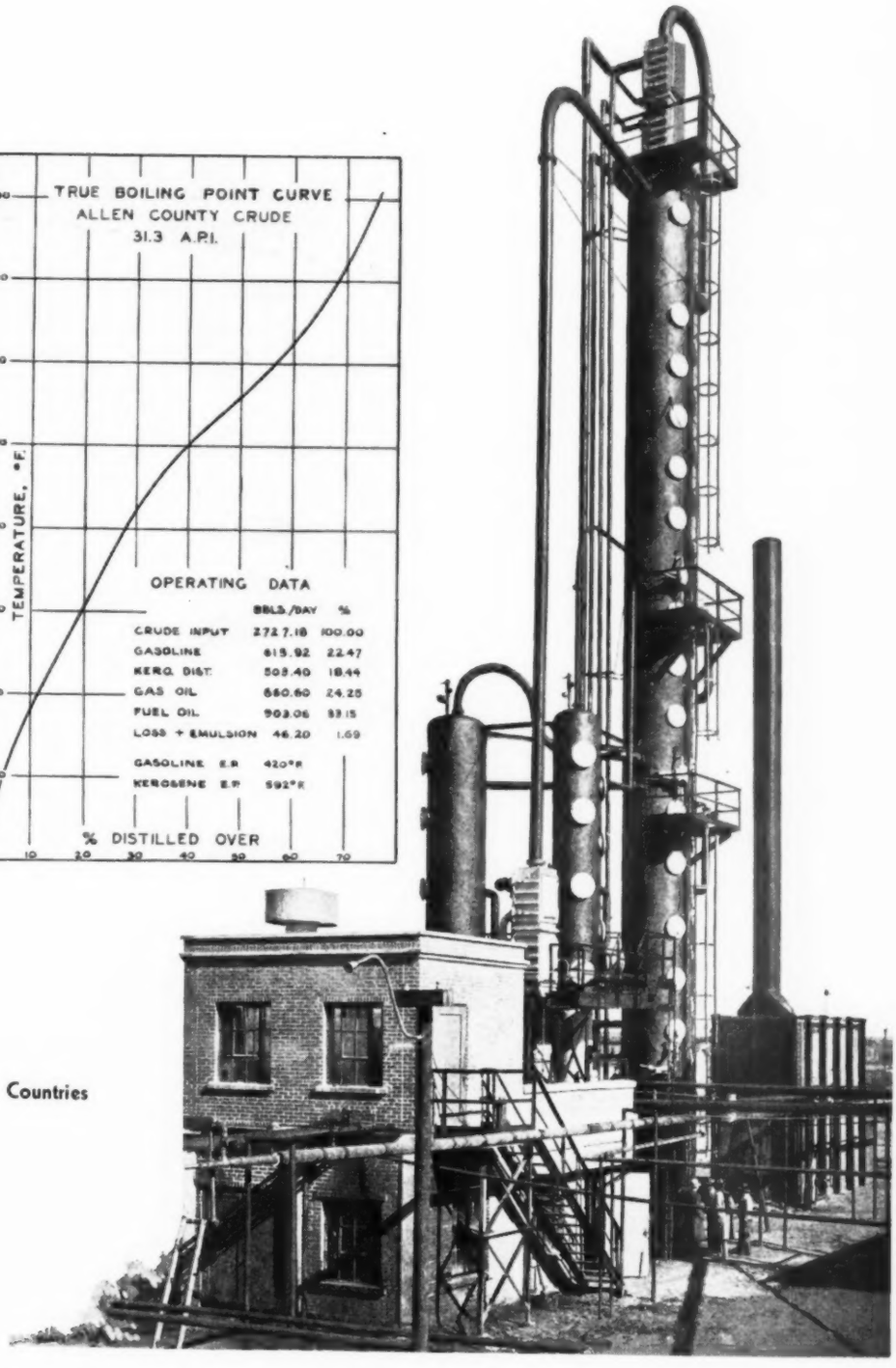

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TABLE 2.

LEESVILLE No. 2

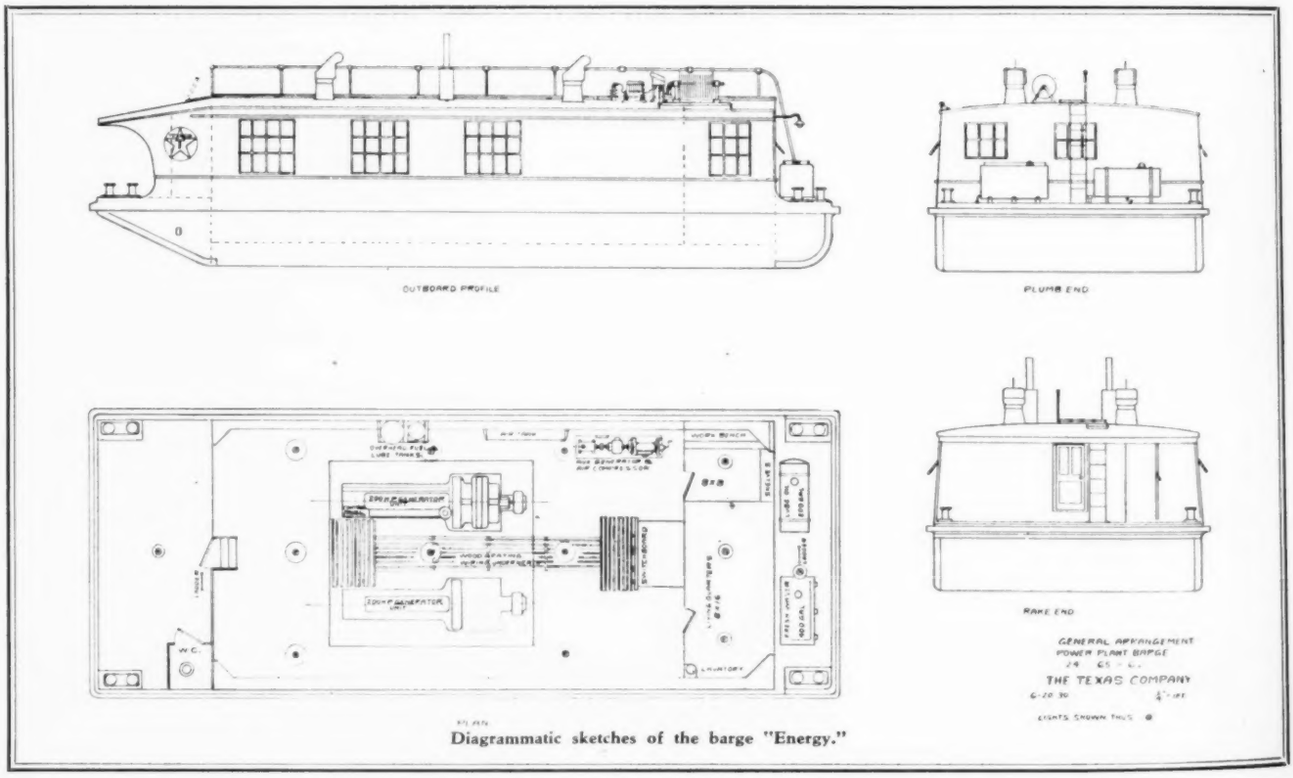
Pulling 5-Inch, 22.2-Pound Drill Pipe

34 Fourbles Using Six 1-Inch Lines — Driller: Bentley

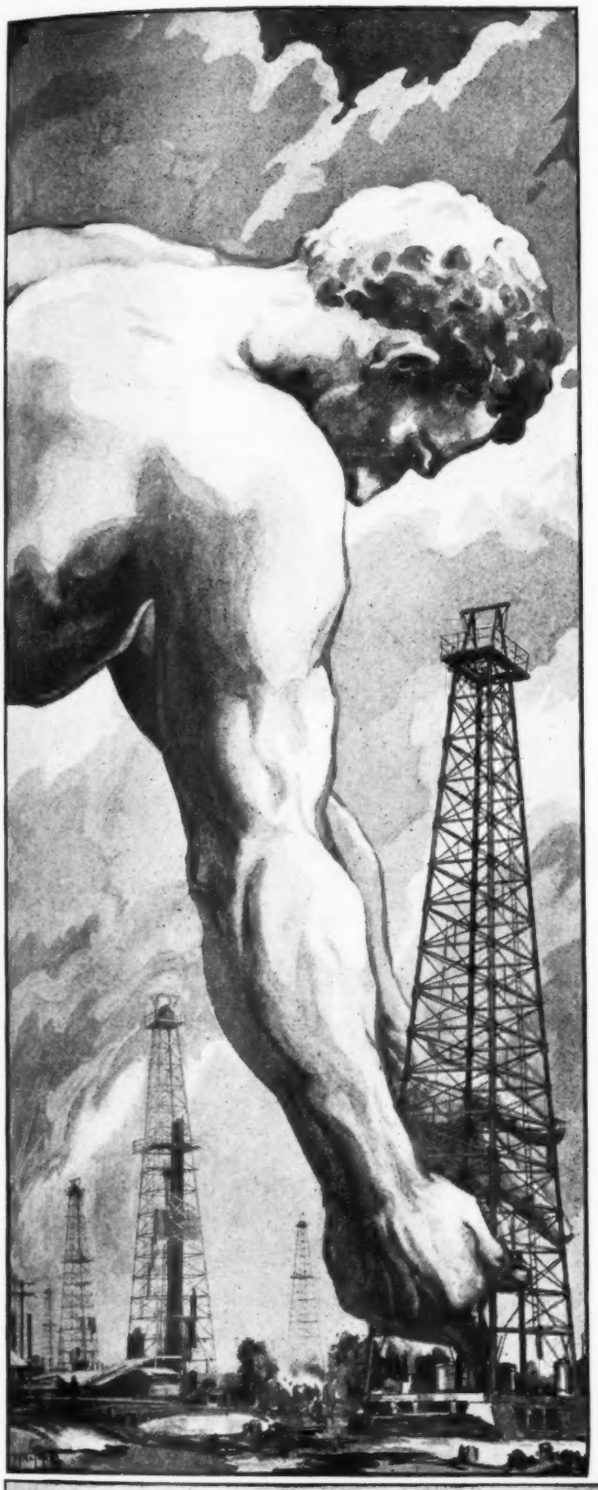
Stand No.	Time in Lifting	Seconds Rd. Trip	Speed Used on Draw'ks	W.T. Indicator Reading	Steady Ammeter Reading	Remarks
1	.....	.....	2	30	230	
2	66	100	2	29	220	
3	105	165	1	28	140	
4	68	190	2	....	200	Slips sticking.
5	67	108	....	....	195	
6	65	103	....	26	190	
7	68	113	....	25	175	
8	69	110	....	....	170	
9	69	106	....	....	160	
10	68	108	....	23	160	
11	55	215	3	....	310	Filling hole.
12	54	103	....	....	290	
13	40	74	....	21	290	
14	43	.....	....	....	300	
15	35	76	....	20	280	
16	37	79	....	....	260	
17	39	81	....	18	260	Filling hole.
18	31	70	....	....	250	
19	33	82	....	....	250	
20	32	74	....	17	230	
21	34	82	....	15	220	Slips sticking.
22	35	86	....	....	210	Filling hole.
23	31	71	....	13	200	
24	33	81	....	....	190	
25	32	78	....	....	180	
26	.....	94	....	....	175	Slips sticking.
27	32	78	....	....	.....	
28	24	72	4	....	250	
29	59	.....	....	....	.....	Slips sticking; lifted table.
30	22	64	....	....	.....	
31	25	70	....	....	180	
32	20	67	....	....	.....	
33	20	.....	....	....	.....	Change slips.
34	20	.....	....	....	150	Bit.

Start—10:00 p. m.
End—11:15 p. m.

Running in time 1 hour flat.
Two joints 6-inch, 25.2-pound pipe just above bit.



Diagrammatic sketches of the barge "Energy."



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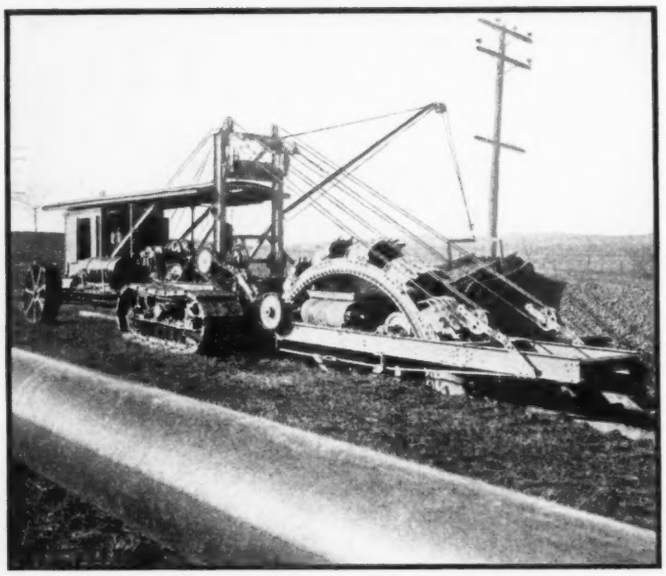

Right Through Hardpan and Limestone

One of the two Buckeye heavy-duty Model 48 Pipe Liners employed on this job is pictured in profitable action on a 24-inch natural gas line. Cutting through hardpan and some limestone, it is averaging 1,000 lineal feet of 36-inch wide by 8 feet deep ditch in 8 hours. On other jobs, where soil conditions were favorable, this model has excavated as much as 5,000 lineal feet of trench in one day.

Largest of Buckeye's complete line of Pipe Liners, Model 48 is expressly designed and constructed to deliver plenty of completed big trench at remarkably low cost. Its 6 cutting widths scale from 22 to 40 inches, inclusive, with a maximum digging depth of 8½ feet.

Built directly to the specifications of the industry's leading engineers and contractors, every Buckeye Pipe Liner—large or small, and within its respective service range—embodies the same dependable working ability. Over 30 years' successful experience has proved the soundness of the Buckeye operating principle and construction. More important, it has caused all Buckeyes to be recognized internationally as *the ditchers that best meet all oil, gas and pipe line requirements.*

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Thomas T. Gray Dies

Thomas T. Gray

THOMAS T. GRAY, refinery process inventor and president of The Gray Processes Corporation, died at 8 p. m. on April 27. Mr. Gray's death came from pneumonia after a four-day illness. Funeral services were held at his home, 1353 North Ave., Elizabeth, N. J., on April 30.

The death of Mr. Gray is a great loss to the refining branch of the oil industry. He was recognized as an outstanding figure due to his several refinery process inventions. The Gray tower for vapor phase refining in use in many refineries throughout the world was invented and patented by him. The tower is used in connection with any type of cracking unit. It eliminates acid treatment and rerunning.

In addition to his own family Mr. Gray is survived by his father and four brothers. The entire Gray family has for many years been prominent in the refining industry, probably having contributed more to its advancement than any one family.

The father, P. R. Gray, Sr., was in charge of refinery operations for the Eclipse Oil Works as early as 1872. He pioneered many processes used in refining lubricating oils and continued in various refining occupations until his retirement about 25 years ago.

All of the brothers of Thomas T. Gray are followers of petroleum refining. A. M. Gray is associated with the Gray Processes Corporation. P. R. Gray, Jr., now deceased, was in charge of the Gray Processes Corporation engineering department. McDowell Gray is superintendent of the lubricating department of the Continental Oil Company, Ponca City, Okla. E. B. Gray is assistant superintendent of the Barnsdall refinery at Barnsdall, Okla., and John L. Gray is executive vice-president of the Deep Rock Oil & Refining Company, Tulsa.

Pittsburgh-Des Moines Steel Moves New York Office

Pittsburgh-Des Moines Steel Company has moved its New York office from 50 Church Street to 270 Broadway. Howard W. Ford will continue in charge as district manager.

When writing BUCKEYE TRACTION-DITCHER CO. *please mention The Petroleum Engineer*

Tagliabue to Have a Branch Office in Detroit

ANNOUNCEMENT has just been made that the C. J. Tagliabue Manufacturing Company, of Brooklyn, N. Y., opened May 1st, a branch sales office at 2832 E. Grand Blvd., Detroit, Michigan.

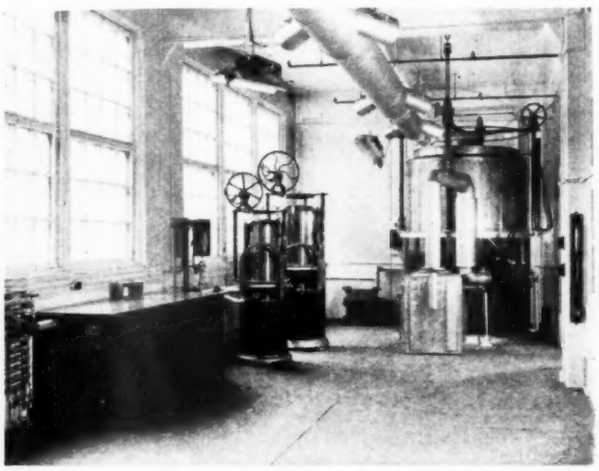
Greatly increased business in this section has necessitated this change from a jobbing connection to a direct sales branch with ample stock of all Tag Indicating, Recording and Controlling Instruments. Convenient inspection and prompt deliveries will now be assured.

H. W. Kerro, who has had many years' experience in solving temperature problems has been placed in charge of this completely equipped Tag Branch Office.

American Meter Expands Research Facilities

ADDITIONS to the floor space, equipment and personnel of the Albany laboratory of American Meter Company have recently been completed. The laboratory now occupies an area of 950 square feet. In it will be carried on experimental and testing work relative to low-pressure measurement. Activities are co-ordinated with the company's research laboratory at Metric Metal Works, Erie, Pa.

To maintain a uniform room temperature essential for proving tests, the Albany laboratory is equipped with an automatic temperature regulation and ventilation system.



By this means stratification of the air is prevented and the temperature maintained within narrow limits.

The air supply for the provers is furnished by a low-pressure blower, which draws the air from the vicinity of the provers and admits it to the provers at a pressure only slightly above atmospheric.

Oil Field Brines Become Real Asset

OIL field brines, long a source of annoyance because of the difficulty of disposing of them without polluting surrounding areas, have been found to be a comparatively fertile source of iodine.

Research work to prevent pollution of coastal areas in California, disclosed the brines contained a substantial proportion of iodine sufficient for commercial production of iodides. It is held possible that in time this source of supply will equal national consumption.

An iodine recovery plant, already in operation here, is producing some 1,200 pounds a day and is to be expanded. In Louisiana wells are being drilled to obtain the brine.

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TRADE MARK REG. IN U.S. PAT. OFFICE

CHAIN TONGS

ARMSTRONG CHAIN TONGS are made stronger, handier and more painstakingly than other tongs. Handles are forged from selected high carbon steel that gives them the requisite stiffness with strength. The jaws, which have greater bearing on the handle than other tongs, are held securely in place by an oversize steel bolt.

ARMSTRONG Tongs have proven strength, are certain to stand up and give extra service. Chains are proof-tested beyond all possible requirements—to ⅔ catalog strength—from 1,200 to 40,000 lbs. Even the jaws, which are held securely in place by a large steel bolt, are tested for toughness and lasting qualities. Jaws are drop forged from special steel, are accurately milled, heat treated and hardened. Handles, too, are forged — high carbon steel that gives both stiffness and strength. Improved design features include: Greater bearing of jaws on handle, forged-in lugs that serve as chain guides and prevent chains from jamming, and drop forged chrome-vanadium steel shackle (connecting link).

Detail of jaw shows increased bearing of jaws on handle and chain-guide lugs.

Write for descriptive circular

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408 Petroleum Bldg., Fort Worth, Texas

When writing ARMSTRONG BROS. TOOL CO., *please mention The Petroleum Engineer*

Methods of Determining

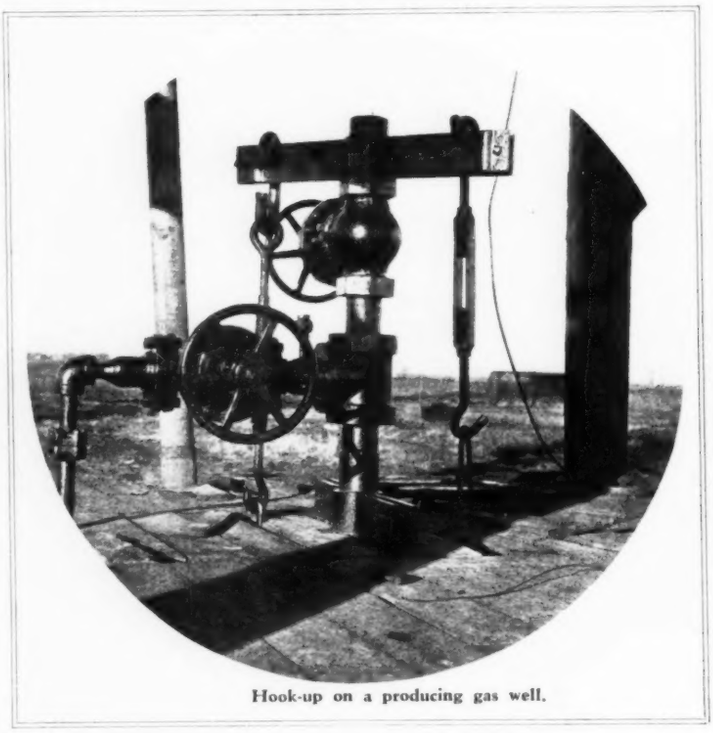
Gas Well Open Flow Capacities

By E. C. CORTELYOU,
Production Department Cities Service Gas Co.

NATURAL gas has been produced and used in this country for more than three-quarters of a century. The past few years' period has seen it attain a prominence far in excess of anything known in its earlier history. We have reached an undreamed-of peak in the utilization of this natural resource.

Some very wasteful methods of taking open flows have been practiced in the production of natural gas; not that the methods used were believed in, but for the want of more efficient methods.

Recently, the United States Bureau of Mines has co-operated with the American Gas Association in the solution of many gas problems. The most noteworthy, from a production standpoint, is the back pressure method of determining gas well capacities. Inasmuch as the state conservation departments have adopted rules that specify that open flow capacity should be determined at definite intervals, usually monthly or quarterly, it is highly desirable to have a method whereby the gas may be metered into the line and not blown into the atmosphere.



Hook-up on a producing gas well.

There are various methods now in use in determining open flow capacities of gas wells, namely, Pitot Tube method, Ninety Per cent Rock Pressure, Parsons Plan, and the Back Pressure Method.

The Pitot Tube method is the basis of measurement for open flow. The impact pressure of the gas discharged from the producing string of pipe is observed and the volume corresponding to this impact pressure is obtained from a table which gives the rates of flow for the various impact pressures corresponding to the different sizes of producing strings. Blowing a well wide open to the atmosphere for the purpose of testing its capacity has never been desirable, as it is believed that such tests are not a representative basis for all wells to determine their most efficient producing condition. However, its application is very simple.

The Indian Territory Illuminating Oil Company, which owns and operates some 300 wells in Osage County, Oklahoma, alone has originated the Ninety Per Cent Rock Pressure method of gauging well capacities. It is now being used with the approval of the Indian Agency. In gauging wells by this method the rock pressure is taken, then the well is turned into the line at different rates of delivery and the back pressure noted on each rate. A curve is then plotted on regular co-ordinate paper, with the back pressure plotted against the rate of flow. The rate of flow at 90 per cent of the formation pressure is taken from the curve and used as a basis for the maximum allowable rate at which the well should be produced, which is approximately 20 per cent of the open flow capacity of the well.

However, this does not hold true for gas wells in all parts of the country. The method is a forward step in the right direction in so far as it eliminates the necessity of opening the wells to the atmosphere. During the latter part of the year 1928, C. P. Parsons, then with the Magnolia Petroleum Company, proposed a plan for determining open flow capacities of wells which was based upon data from the history of wells in the Chickasha (Okla.) gas field. He determined the relation between the decline in rock pressure and the decline in open flow. This relation was a composite curve for all of the wells in the field and was arrived at by correlating data on 20 representative wells in the pool. Therefore, with this curve as a basis the open flow could be computed by measuring the decline in rock pressure.

It has been found that this curve cannot be used in all gas fields, as the sand and producing conditions vary. The principal difficulty encountered in using the plan is that it is necessary to establish a pressure volume declining curve for each field, and this cannot be done during the early life.

The Back Pressure Method of determining gas well capacities was originated by the United States Bureau of Mines. They have published two papers discussing the technical phases of this method of analyzing gas well capacities.

Wells being gauged by this method are shut in and a reading is obtained of the shut-in or well-head pressure, then four or five measurements are taken of the rate of gas flow from the well at four or five corresponding back pressures. The back pressure on the well should be at least 80 per cent of the shut-in pressure at the maximum rate of flow. It is important that each reading be taken when the well has reached a settled condition. After calculating the actual pressure on the sand for each reading the rates of flow on the abscissæ are plotted on logarithmic paper against the respective differences between the square of the shut-in pressure at the sand and the back pressures at the sand face. When the data are plotted in this way the

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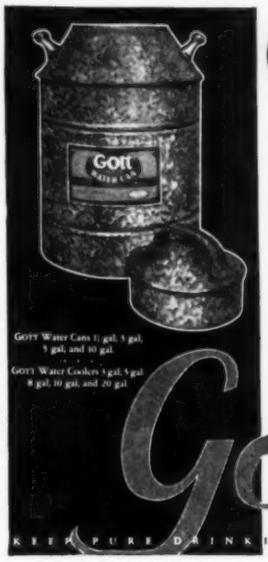

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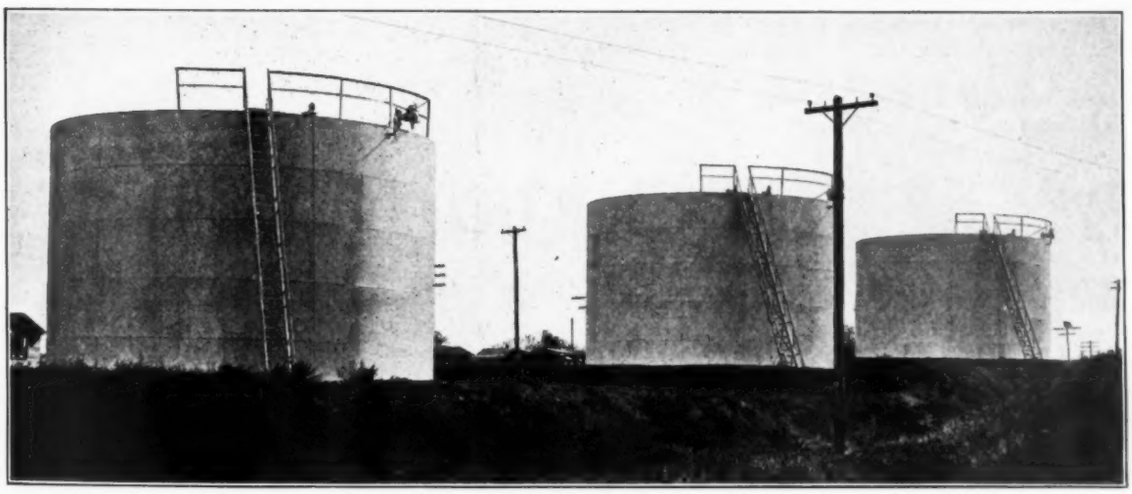

THREE 5,000 BARREL OIL TANKS

erected in an Oklahoma oil refinery during 1930. Each tank has a welded cone roof and is equipped with a sturdy, compact and modern "Pittsburgh-Des Moines" steel stairway and railing. Forty-one tanks of various capacities were erected on this one contract.

Other "Pittsburgh-Des Moines" products for the oil and gas industry are:

Steel Stacks, Steel Pipe Lines, Refinery Equipment, Gas Holders and Tanks, Gasoline and Fuel Oil Storage Tanks, Booster Stations and Pumping Plants.

PITTSBURGH-DES MOINES STEEL COMPANY

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THE HEEL JAW IS EASY TO REPLACE

The Removable RIDGID *Heel Jaw*

When the heat-treated special steel heel jaw on a RIDGID Pipe Wrench finally wears down, there's no need to throw away the whole handle and housing. Simply punch out the pin, put in a new heel jaw and re-pin it — a two minute job. That's only one of many RIDGID features; guaranteed unbreakable housing . . . . . full-floating hook jaw that won't bend or break, with accurate pipe scale on it . . . . . jaw action that grips or lets go instantly and that won't slip or lock on the pipe . . . . . adjusting nut that turns easily in wide open housing . . . . . powerful I-beam handle with hang-up hole. No wonder several hundred thousand pipe wrench users are enthusiastic about the RIDGID.

There are RIDGID Pipe Wrenches Cutters, Vises & Threaders

Take a good look at this RIDGID *Pipe Wrench and the other* RIDGID *Pipe Tools at your Supply Store.*

The RIDGE TOOL COMPANY, Elyria, Ohio

RIDGID PIPE TOOLS

relation is represented by a straight line. The extension of this straight line on the logarithmic paper makes it possible to read directly the rate of delivery or open flow corresponding to the formation pressure.

During the past year Cities Service Gas Company has made a practice of testing all of the high-pressure wells to which its lines are connected by the Back Pressure Method. During the month of November, 1930, a joint test was made on all of the wells in the Depew field, located in Creek County, Oklahoma.

The Depew gas field was discovered during the year of 1925 and since then there has been some thirty wells completed in the gas-producing horizon. The gas is being produced from the upper Dutcher sand, found at a depth of approximately 3300 feet. There were 27 producing wells in the field on the date of the test.

The original formation pressure was 1320 pounds, while on the date of the test the rock pressure was 510 pounds, indicating a high degree of depletion.

Most of the wells were completed with 6⅝-inch casing, which is cemented, in most cases, about 100 feet above the sand pay. The edge wells on the structure were showing considerable water and many of them were tubed with two-inch bleeder lines.

In making the back pressure tests no standardized method or procedure was followed; however, where possible, the readings for the high rates of flow were taken first. This was done in order to pull over the water and gasoline that had condensed in the bore of the well. The rates of flow in all cases were measured by orifice meters and the flow delivered into the line.

The working pressures at the well head were measured by means of spring gauges which were calibrated once each day. The rock pressures were gauged with the same gauge used during the flow test. It has been found when testing wells through the syphon lines that it is more satisfactory to take the working pressures on the well head and not on the flowing gas.

In testing the edge wells, many of which were wet, the shut-in pressures were 30 to 40 pounds less than the pressures on the wells equipped with two-inch syphons. It usually required at least one or two hours longer to obtain a satisfactory test than it did on dry wells.

From an operating standpoint this method of gauging wells at Depew was very satisfactory.

Dresser-Merco Nordstrom Consolidation Approved

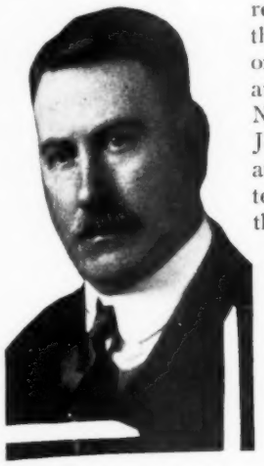
A CONSOLIDATION of businesses of the S. R. Dresser Manufacturing Company, Oil City, Pa., with that of Merco Nordstrom Valve Company of San Francisco, Calif., has been approved by the boards of directors of the companies.

A new Delaware corporation to be known as Dresser-Nordstrom Company will be formed to take over the capital stock of the two companies. Necessary papers have been sent out to Dresser stockholders so that the transfer may be accomplished at once. Merco Nordstrom stockholders have already approved the plan.

The Dresser company for more than fifty years has manufactured pipe line equipment, its principal product being Dresser couplings. The Merco Nordstrom Valve Company has enjoyed a remarkable growth during the last six years. The company has specialized in making lubricated plug cock type valves.

Prairie Pipe Superintendent Dies

DANIEL P. LEARY, for the past ten years division superintendent of the Texas division of The Prairie Pipe Line Company, with headquarters at Eastland, Texas, died on April 17.



Daniel P. Leary

Mr. Leary had an excellent record for continuous service in the oil industry. He was born on July 17, 1872, at Renova, Pa., and entered the service of the New York Transit Company on July 4, 1904, as engineer-operator. He became gauger the latter part of 1908 and continued in that capacity when he resigned to enter the service of The Prairie Oil & Gas Company in the same capacity. He was promoted to district foreman the first of January, 1914, and one year later was transferred to The Prairie Pipe Line Company in the same capacity. On June 30, 1921, he was made division superintendent of the Texas division and was acting in that capacity at the time of his death.

In his nearly 30 years' service to the oil industry Mr. Leary had made many acquaintances and friends who will grieve his loss.

Lufkin Has New Los Angeles Address

LUFKIN Foundry and Machine Company, Lufkin, Texas, has moved its Los Angeles, Calif., branch office and warehouse to 5959 South Alameda. Day and night service will be maintained at the new location. The company will still retain its Bakersfield warehouse at the Pioneer Truck Company, 16th and "Q" streets.

International Derrick-Stacey Engineering Merge

MERGER of the International Derrick & Equipment Company and the Stacey Engineering Company has been approved by the stockholders of the companies. Headquarters of the consolidated companies, which will be known as the International-Stacey Corporation, will be in Columbus, Ohio. Carmi A. Thompson, president of Stacey Engineering Company, will be chairman of the board and Harry M. Runkle, president of International Derrick & Equipment Company, will be president and general manager.

International Derrick manufactures oil industry drilling and producing equipment, while the Stacey Engineering Company makes gas holders, meters, blowers and similar equipment.

Dardelet Appoints S. M. Jones Company Distributor

THE Dardelet Threadlock Corporation has granted to the S. M. Jones Company of Toledo, Ohio, a license to manufacture and sell sucker rods with the Dardelet self-locking screw thread.

With each shipment of Dardelet threaded rods the S. M. Jones Company will deliver a certificate of insurance guaranteeing the payment of $30.00 for each joint broken while in service. This sum represents the cost of the broken rods and the average expense of recovering the broken string from the oil well.

SKINNER SERVICE SADDLE

for service connections on oil and gas

DESIGNED expressly for the industry. The pressure platform concentrates pressure on the gasket, while sliding skids on the lower half of the saddle prevent tilting and bring an even bearing to the rest of its contact with the pipe. When you use a Skinner Service Saddle, the pipe is supported, the installation is rigid, permanent. Made of malleable iron.

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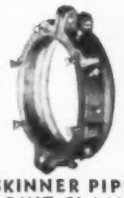
SKINNER COLLAR LEAK CLAMP



SKINNER PIPE JOINT CLAMP

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Costs Nothing to Get the Facts!

WE do not expect you to buy a Jensen Jack until you have satisfactory proof that it will be more efficient than any equipment you have or can buy elsewhere.

Hear our story — see our proofs — learn why major companies are standardizing on JENSEN JACKS.

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Coffeyville, Kansas, U. S. A.

JENSEN JACKS

THE DOHENY STONE DRILL COMPANY of Los Angeles, Calif., has issued a bulletin that gives a description of the Hydril line of drilling equipment comprising the No. 3, Rotary and Drawworks, capable of drilling to 12,000 feet or more; Three-Cylinder Vertical Steam Engine; No. 2-C Rotary and Draw Works, for 6,000 feet; Gas Pressure Control; Dual Hoist and Core Drilling Rotary; All-formation Core Barrel; Angle Indicator; Flush Joint Casing and Couplings; Flush Joint Drill Pipe and Tool Joints; Slip Socket Overshot, and Circulating Plug.

AN INTERESTING BOOKLET has been published by the Jefferson Union Company, which has sales offices at 11 West 42nd Street, New York City.

This booklet, Catalog No. 26-A, besides descriptive and specification matters, contains recommended pressure rating data on Jefferson Style "A" Unions and on Jefferson Flange Unions, styles "B" and "C".

The listings in this booklet supersede all previous pressure ratings and apply only to Flange Unions equipped with special alloy steel bolts. These test ratings have been secured from tests made by the Malleable Iron Research Institute.

"ELEMENTS OF CHEMICAL ENGINEERING," by Badger and McCabe, has been published by the McGraw-Hill Book Co., New York. The clear and concise methods of presenting the fundamental conceptions and the elucidation of the mathematical methods useful in solving engineering problems make the book a very valuable reference for the petroleum engineer. The excellent presentation of such subjects as Flow of Fluids, Flow of Heat, Transportation of Fluids, Distillation, Gas Absorption and Filtration will appeal to the chemist or engineer whether he is engaged in the refining, transportation or production branch of the industry. Price $5.

A NEW 80-PAGE CATALOG is just off the press by W. H. Detrick Company, 140 South Dearborn Street, Chicago. It is arranged as a handbook for refractory furnace engineers and is attractively printed in color treatment. Several sections are devoted to explaining the underlying principles of Detrick air-cooled walls and arches. The catalog has useful tables and charts for calculating the heat transfer through refractories, figuring the air required for cooling, and giving general information that the designer constantly requires.

THE CHAPLIN-FULTON MANUFACTURING COMPANY, Pittsburgh, Pa., are distributing two new bulletins. These describe the Fulton Dash Pot or Sensitizer and the Fulton Differential Relief Valves. These bulletins, which give pictures, specifications and work of the equipment, may be secured from the manufacturing company.

THE BROWN INSTRUMENT COMPANY, Philadelphia, Pa., will mail to those interested its new catalog No. 46, entitled "Brown Tachometers."

The descriptive matter covers Brown Indicating and Recording Tachometers in various models, together with the electric generators used in operating same.

A FOLDER, D. M. F. 5299, covering briefly the use of steam jet air ejectors in industries using vacuum processes, has been issued by the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa.

Among the several types of air ejectors discussed are: Two-stage condensing types with either surface type intermediate and after condensers or jet type intermediate condensers only; single-stage condensing or non-condensing ejectors; and compound ejectors on jet intermediate and after condensers.

PETROLEUM ENGINEERING, INC., of Tulsa and Fort Worth, has published a bulletin for those not yet familiar with its service and products, which are described. This booklet will be revised and reissued from time to time.

SPERRY-SUN WELL SURVEYING COMPANY, 1608 Walnut Street, Philadelphia, has had printed a new booklet known as "Surwell Service." This booklet describes briefly the Surwell Service, its operation, advantages and manifold uses in surveying crooked holes.

"MECHANICALLY OPERATED FLUID METERS" is the title of a new bulletin now being distributed by the Bailey Meter Company of Cleveland, Ohio.

This bulletin, designated as No. 37, describes and illustrates various types of mechanically-operated meters and auxiliary equipment for their installations. Colored meter chart records showing results obtained by the application of Bailey meters to various processes are included, together with sections on orifice and flow nozzle location, calibration, pulsating flow, special conditions and special applications.

THE CONTINENTAL ELECTRIC CO., INC., 323 Ferry Street, Newark, N. J., has issued a pamphlet, No. 500, which describes both alternating current and direct current Explosion-Proof Motors. Full description and specifications, with pictures, are given in the bulletin.

THE OIL WELL SUPPLY, Oil City, Pa., has published a very interesting booklet on oil well boilers. The book is well illustrated, carrying pictures of boilers in all principal producing countries of the world.

Editorial matter discusses the advantages and working features of various types of boilers, such as thermic siphon boilers; superheater boilers; locomotive type, and horizontal tubular type.

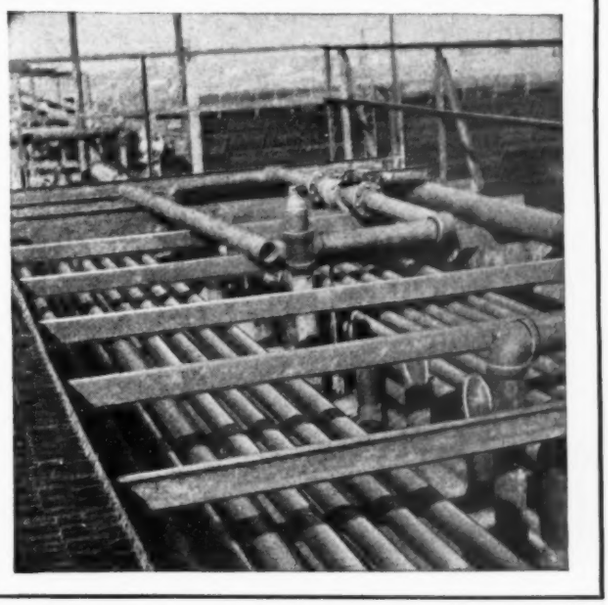
A PLAN to enable users to put 1931 efficiency into older models of Cooper-Bessemer gas engines is outlined in a folder issued recently by The Cooper-Bessemer Corp. A replacement steel cylinder head, power cylinder and gas economizer are included in the plan, which may be applied wholly or in part to any Type-8, Type-10, or Type EC engine now equipped with 16-inch cylinder. The Cooper-Bessemer Corporation, Mt. Vernon, Ohio, will supply further information on request.

LINK-BELT COMPANY, Philadelphia and Chicago, has just issued a folder, No. 1248, describing its "Cub" Portable Belt Conveyor.

The folder contains a description of the machine, its parts, and gives a comprehensive list of the many industries in which this type machine has been used for handling various materials.

Illustrations of these machines at work under many conditions are shown, along with complete specifications.

A copy will gladly be mailed by the company upon request.



Arco Metal Pipe

possesses outstanding advantages

It gives you the desirable features of *cast iron* with the convenience of steel pipe—long life and resistance to corrosion without cumbersome size.

It is light in weight—having the same dimensions as extra strong steel pipe and weighing approximately the same.

If desired, it can be cut and threaded like steel pipe with standard pipe tools. It then makes up with any standard screw fitting. Or it can be welded or provided with flanges for other types of connections. In a word, it is *adaptable* to your conditions.

How conveniently Arco Metal Pipe can be made up is shown above—a condenser coil of exact 32 ft. lengths with close centered Arco Metal Return Bends.

Let us help you with your problem. Write us—it will put you under no obligation.

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Selection of . . . .

Input Wells *for* Repressuring *with* Gas

THE success of repressuring programs in old depleted oil producing areas depends to a very large degree upon the proper selection of input or key wells for the injection of the natural gas used as driving agent. Therefore, the selection of these wells should be given much study and thought, and by all means should not be haphazardously picked out.

The restoring of pressure to old oil reservoirs for the purpose of increasing the ultimate commercial crude production has proven very profitable in many areas throughout the oil producing states of the Union. There are many oil fields, and even a fewer newer ones, where pressures have dwindled to the point that it has become necessary to rebuild them, so as not to leave an unusually large quantity of unrecoverable oil in the ground.

Repressuring, or pressure restorage work, while highly successful in many areas, is not work to be undertaken by inexperienced help. The many improvements and advancements along this line of work have been the result of experience and much study of oil formations and gas drives.

Repressuring is not a cure-all for production methods and practices. It requires much time and attention to keep in the right working order. It must be remembered that the original conditions of existence of gas and oil cannot be restored by the pressuring processes, but repressuring is probably the next best thing to the original conditions after pressures have fallen and it will store an available gas supply in the formations. The first step upon the decision to repressure a property or area should be to make a thorough preliminary study of the region. The chances of success are better where the most information is obtained. The importance of making this survey of the district cannot be over-emphasized. If no authentic record can be secured on a well it should be classed as a doubtful agent well.

A survey of this nature should include the following information, and other data if possible, on all producing, dry and abandoned wells: 1. The history of each well from time of completion. 2. Knowledge of the method of producing the well. 3. The thickness of the producing sand in each hole. 4. Location of the loose and tight streaks in the pay horizon. 5. Location of the edge of encroaching water.

The history of each well should include its initial production and gas-oil ratio, with all increases and decreases in production noted on various producing methods that might have been used. The knowledge of producing methods is necessary because of the advantages of various methods over others, and may also help in determining the condition of the hole.

Continental Oil Company high pressure station at Seal Beach, Calif.

It is seldom that an oil producing formation is found to be uniformly solid throughout the area. Therefore, the location of tight-sands should be checked. Big initial production and quick depletion of flow is ordinarily a good indication of loose texture of the sand. Low gas-oil ratios serve to indicate areas of relatively high oil saturation in comparatively loose sands. Tight sands and low saturation of the sands about the well are usually indicated by high gas-oil ratios in the early producing life of the wells. However, many tight sand areas may be well saturated with oil and yet produce with a high gas-oil ratio because of the ability of gas to migrate more readily than oil through the tight porousness of the horizon. The location of tight-sands may be checked by closing in the well and noting the time in which it builds up formation pressure. The slower the building up of the pressure the tighter the porosity.

This preliminary study of the oil producing area should include data on all wells producing quantities of water. It should be determined whether the water is bottom, top or edge fluid.

Selecting Injection Wells

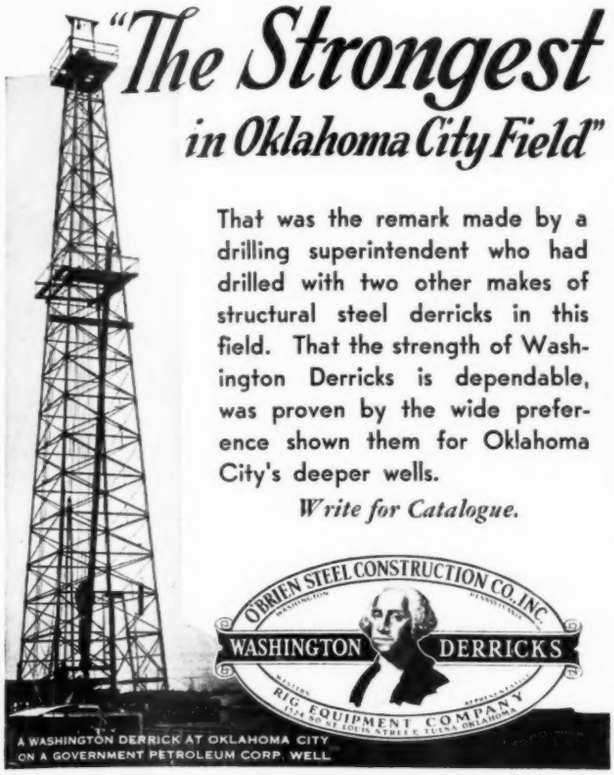
After gathering all available material on the life of the various wells in the area to be repressured, actual work on the selection of injection wells may be started.

The input or key well should be selected so as to affect the greatest possible number of surrounding wells.

One of the big items to be considered in such work is property lines. The location of injection wells with respect to property lines must be worked out so that the drive will not force the crude to properties adjoining that may be owned by other interests than your own company. This problem is greatly simplified where large, solid pieces of acreage are held by one company or where a co-operative repressuring system is adopted by all operators. Then, repressuring may be carried on without regard to property lines.

Line wells should not be chosen as injection wells. Gas will naturally migrate to areas where pressures are low, which would be the case on adjoining properties not using pressure. High fluid levels will have to be carried on line wells to prevent the benefiting of the neighbor not repressuring his property. Injection wells should not be less

"The Strongest in Oklahoma City Field"


O'BRIEN STEEL CONSTRUCTION CO. INC.
WASHINGTON DERRICKS
RIG EQUIPMENT COMPANY
A WASHINGTON DERRICK AT OKLAHOMA CITY
ON A GOVERNMENT PETROLEUM CORP. WELL

That was the remark made by a drilling superintendent who had drilled with two other makes of structural steel derricks in this field. That the strength of Washington Derricks is dependable, was proven by the wide preference shown them for Oklahoma City's deeper wells.

Write for Catalogue.

O'Brien Steel Construction Co., Inc.
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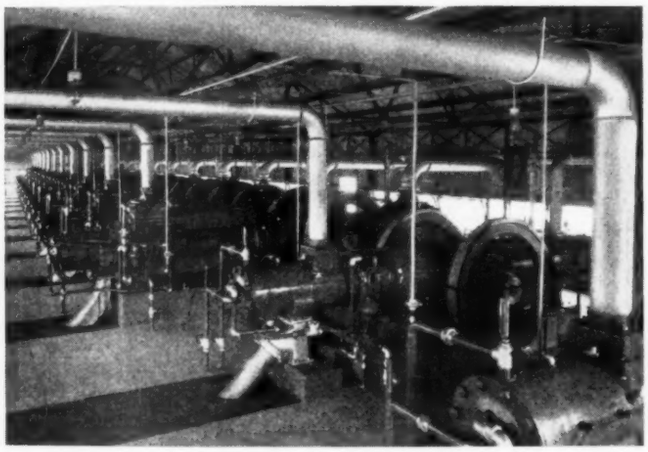

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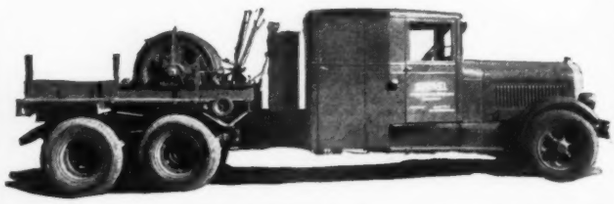

than two locations from property lines in such cases. If a property is flushed with water it is considered undesirable for repressuring application, unless the encroachment is very slow.

Where properties are surrounded by edge water it is usually best to repressure by injecting the gas or air into wells immediately above the edge-water front. This tends to hold back the encroaching water front.

Wells that produce water generally make poor injection wells. High pressures are ordinarily required to force the water through the oil sands. If water in large quantities is present there is imminent danger of flooding the sand that contains oil; thus trapping much of the oil and making it unrecoverable.

Considerable study and thought must always be given to questions of whether wells that are small producers or large wells are to be used for injection purposes. There seems to be a difference of opinion along this line. If smaller producers are taken, high pressures for injection will probably be required, because these wells are usually in the thinner and tighter portions of the field. However, less gas energy will be needed to produce a barrel of oil by forcing it to producing wells in the looser sand areas. The reduction in current production of the property is naturally not so much affected when small wells are chosen. The benefits of repressuring are also noticeable in a shorter time than when large producers are taken off production for injection wells.

Large producers ordinarily drain areas of loose and porous sand, which, during repressuring operations gives a better distribution of the gas at a lower injection pressure than the tight and less porous sand. This reduces the chances of channeling.

If considerable oil has been taken from the proposed input well in comparison with the other producing wells of a property it is probable that a comparatively high degree of depletion exists in that vicinity. Any agent forced into this well will have a certain amount of space to fill before much results are to be observed; however, this is a good condition for a key well. Such a well will permit a greater oil surface contact for the driving agent.

Many engineers favor the plan of injecting pressure into both the tight and loose areas of the sand. Since practically every property is made up of these two conditions it can be done. This plan gives uniform distribution of the pressure, thus all oil producing wells are benefited.

Reversing the flow direction of oil does not have any adverse effect on conditions unless the oil is driven into barren sands.

A porous gas sand grading into a less porous oil sand will give a high oil-gas ratio. In such cases it would be hard to get repressuring results of economical value.

Wells having exposed sand of a broken and shaley nature probably will not take gas at a reasonable pressure and neither will a well with a very thin producing body of sand.

It has been observed that in dipping formations the effect of injected gas is more noticeable in wells up-structure than in wells located at an equal distance down the structure from the injection wells, however, some engineers favor and have success with up-structure wells as agents.

The number of injection wells that are required for repressuring a property depend upon many things. Some of these are: Structure conditions, sand porosity, water conditions, producing capacity of the wells, well spacing and the amount of gas available for repressuring purposes if gas is used.

This cannot be determined by any set rule. Experimentation, by adding and taking away injection wells, can usually determine the best balanced ratio between producing wells and injection wells.

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Republic Steel Conducting New Experiments

THE Republic Steel Corporation is building a new furnace in its laboratory at Canton, O., for the purpose of conducting a series of important experiments with stainless steel tubes for oil refineries. With the new equipment the company's metallurgists expect to develop steels possessing certain properties to meet special requirements of the oil cracking industry.

Republic's Enduro stainless steels are now used in the oil industry where material is needed to withstand high temperatures and pressures, and further developments are looked for which will greatly widen the market in this field.

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The tube to be tested is then placed in the center of the heating chamber and, with the use of CO_2 gas, very high pressures are obtainable and it is possible to break the tube at any given temperature. The tube under test is plugged at each end with a heavy steel plug which is welded in. The CO_2 gas is introduced into the tube through extra heavy ¼-inch pipe and a hydraulic gauge registers the pressure.

Fluid Packed Pump Has New Foreign Connections

The Fluid Packed Pump Company has entered into a contract with "Malopolska," a large holding company governing better than 50 per cent of the production of Poland, wherein this large operator will use stock and distribute Fluid Packed Pumps under certain conditions troughout the Polish oil fields.

This contract is the result of tests recently conducted by one of the companies in the "Malopolska" group. A good part of Polish production is being secured by swabbing, pumping having been unsuccessful heretofore due to the extremely high paraffine content of the oil. The Fluid Packed Pump Company, however, was able to demonstrate that these wells could be pumped satisfactorily.

The Fluid Packed Pump Company has also entered into an agreement with Soc. "Apex" S. A., wherein this company will stock and distribute Fluid Packed Pumps in the oil fields of Roumania. Stocks are being carried in Poland.

Lincoln Arc Welding Prize Competition

THE Lincoln Electric Company, Cleveland, Ohio, is sponsoring a contest by which $17,500 will be distributed as prizes. The purpose of the contest is to increase the knowledge of the adaptability of arc welding to industry, more especially of the adaptability of welding in the redesign of present machinery from cast iron or riveted steel structures to welded steel structures. Full details of the contest and all communications should be addressed to The Lincoln Electric Company, Cleveland, Ohio.

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Valve Stem Packings for Natural Gas

By HAL T. WHEELER*

GAS under pressure against a valve stem packing is persistently endeavoring to escape. The packing has been purchased to stop any leakage, and if it functions properly, will successfully resist any attempt of the gas to escape. To prevent leakage of gas, a packing must react automatically against pressure, which means that the pressure must operate the packing.

To qualify as a flexible joint, packing must perform three services: (1) reduce the impressed pressure to a lower level (usually to atmospheric pressure), (2) transfer the thrust of the pressure against the packing structure to the packing gland, and (3) maintain a seal around the stem while the latter is stationary, or is being moved. It might be asked, is it correct to assume that the packing can perform these three operations without any regard to the method of use? The answer is: Packing will do just as much as its construction will permit, its ability to seal pressure being regulated by certain inherent relations of size and shape. It is apparent, therefore, that adjustment at the packing gland cannot make up for what is lacking in the general scheme of relations, and may be a hindrance as often as it may prove to be a corrective measure.

The idea seems to be prevalent that packing is a commodity, a thing within itself which in some manner stops pressure when placed in a stuffing-box. It is usually purchased by the pound and applied to the job in hand according to the conditions found. This viewpoint is correct so far as purchasing is concerned, but for analysis from an operating standpoint the general term "packing" must be narrowed to mean a flexible joint which must compensate for a number of variable forces, some due to its own construction and others forced upon it.

Nearly all packing can be torn apart by the hands, careless wrapping will cause damage in shipment, and in many ways it is fragile. Yet, when installed in a stuffing-box it will resist exceptionally great pressures and resist wear to a great degree. Obviously there is considerable difference between the physical properties of the commodity called "packing," and the results that may be obtained through its use, the resistance to pressure being far out of proportion to its physical strength. Therefore, packing must be but part of a system which in operation will resist pressure.

For example, a stuffing-box is filled with a number of asbestos rings, lubricated with oil; before any pressure is applied the gland may easily be screwed up and the packing squeezed until nothing but fabric is left. But when pressure is applied and the operation repeated there is a resistance to gland compression greater than the combined pressure and fabric resistance; much time must elapse and considerable effort must be expended on the gland screws before the packing can be reduced to the fabric. The packing became endowed with new qualities as soon as it was exposed to the pressure, and, since in these characteristics are found the reasons why the packing can hold the pressure of a gas, such as natural gas, a detailed study of packing rings follows:

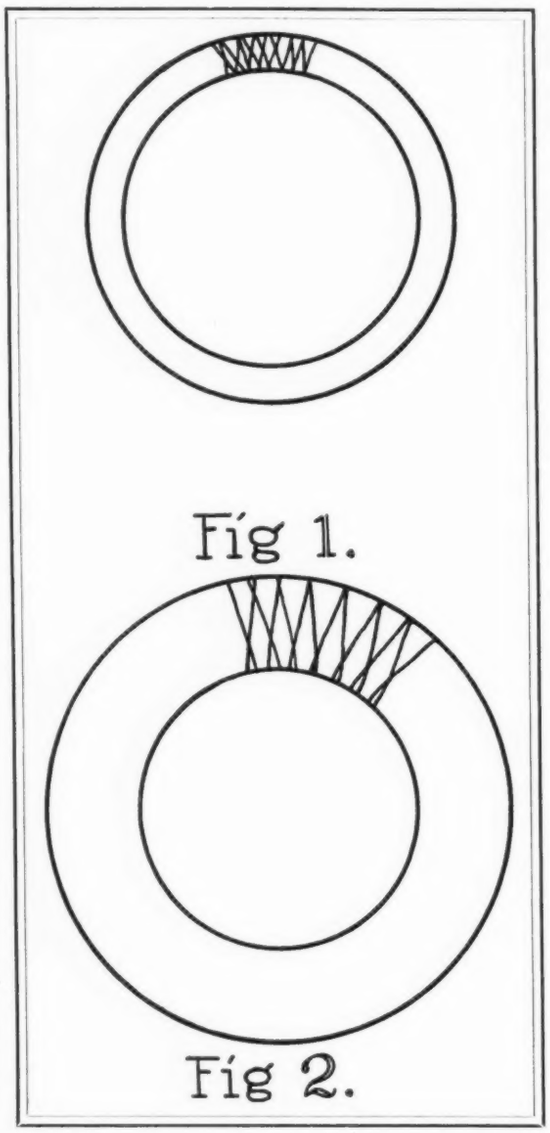

Fig 1.

Fig 2.

(1) When a ring of braided packing is cut and bent around a stem, the fibers on the outside of the ring are stretched, while those on the surface next to the stem are compressed. Referring to Figure 1, a packing of narrow width, there is little difference in the fiber spacing on the inner and outer portions. But in Figure 2, a wider ring, the outer fibers are far apart. When these two rings are placed against pressure, a flow or seepage is easily established along the outer surface of Figure 2. Therefore, the width of a packing ring is one measure of its ability to resist pressure, the narrow ring having a higher resistance to seepage because the pores are smaller and obstruct the change of pressure.

(2) When a piece of packing is bent into a circle, the outer fibers are stretched and the inner ones compressed. The ring becomes a continuous arch. The inner portion has more strength than the outer, due to a greater density of fibers and the interlocking of the weave. For the same radius of curvature a narrow ring is as weak as an excessively wide one. It should be seen that for any one radius there is a width of ring that will have a maximum strength due solely to the relation of the fibers.

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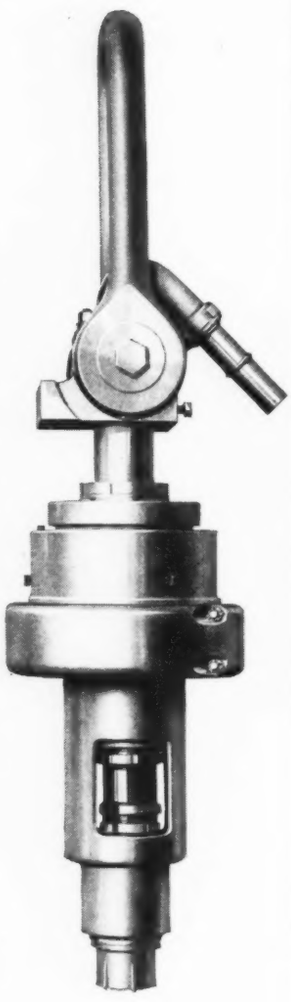

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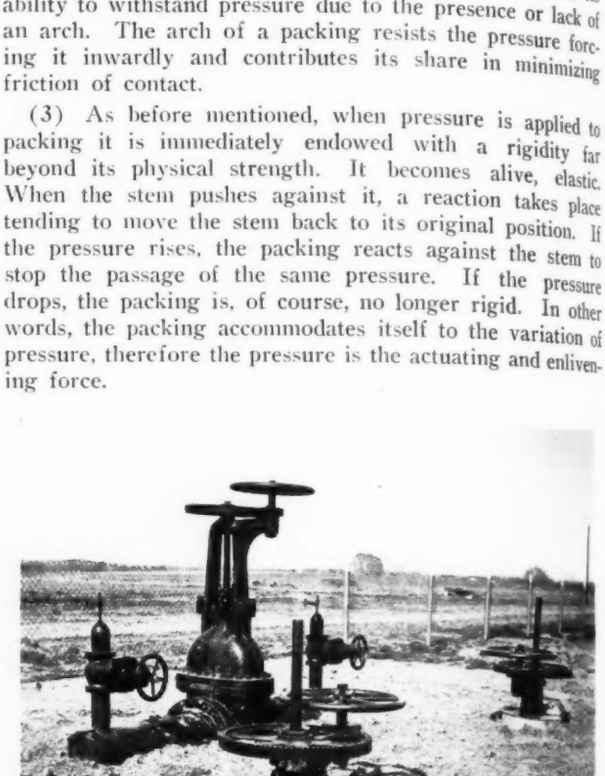
TIW-94

for example—is bent to a variety of radii, as from one inch to six inches, at some one radius the packing will show a maximum strength of the arch. Therefore, the width of a packing ring may also be considered a measure of its ability to withstand pressure due to the presence or lack of an arch. The arch of a packing resists the pressure forcing it inwardly and contributes its share in minimizing friction of contact.

(3) As before mentioned, when pressure is applied to packing it is immediately endowed with a rigidity far beyond its physical strength. It becomes alive, elastic. When the stem pushes against it, a reaction takes place tending to move the stem back to its original position. If the pressure rises, the packing reacts against the stem to stop the passage of the same pressure. If the pressure drops, the packing is, of course, no longer rigid. In other words, the packing accommodates itself to the variation of pressure, therefore the pressure is the actuating and enlivening force.



Valve arrangement at a gas measuring station.

Referring now to the arch formed by a ring of packing: In this example we have a braided ring, an infinite number of fine pores between the fibers. These have been impregnated with oil under pressure. Every movement of a fiber is resisted by the body of the oil, the internal pressure of the latter resisting any change of shape or position. Every movement of a fiber means a slight adjustment of pressure; work is being done on the oil under pressure, with a consequent reaction to movement. The fiber pushes back as much as it is pushed, up to certain limits, and ceases pushing only when the oil has been given enough time to find a new location. The packing ring is in the grip of fluid tension and acts similarly to a liquid under pressure. The packing fibers merely perform the service of holding the oil in place until installed in the stuffing-box and until the pressure shall act upon the combination to form a wall from the stem to the box wall, to shut off the pressure. Fluid tension applies to all types of packing using the impregnation of a liquid, and to those exposed to a liquid under pressure.

A narrow packing ring will develop a high fluid tension because the pores are close together. An excessively wide ring will prevent the possibility of fluid tension because the pores are too far apart to develop a resistance to flow of the oil under pressure, and it leaks to the outside. It should now be seen that fluid tension will automatically build up in a narrow ring, and that adjustment of the packing gland will make no change. On an excessively wide ring the pores must be closed by compression from the gland to

retard the flow of the oil, thereby destroying the flexibility of the arch of fibers and deforming it. The proper width of the packing bears a definite relation to the radius of the stem, which is called the curvature relation. Thus the width of the packing is yet another measure of ability to resist pressure by reason of the actual fluid tension that is created.

An important method of holding pressure is by varying the viscosity of the impregnating liquid. It has been found that the length of time necessary for a constant pressure to force the oil out of a fabric is approximately proportional to the viscosity, other conditions being equal. This also applies to waxes and fats substituted for oils. The change of viscosity due to temperature is considered in the viscosity as measured. However, a damper must be used when varying viscosity; a heavy oil on a wide ring slows down the seepage without appreciably increasing the friction, and this would be the field of application. On a narrow ring, a heavy oil slows down the reaction to pressure and builds up a high friction, comparable to a solid bushing. -Yet the benefit of a heavy oil can be reversed; a one-half-inch packing on a one-inch stem would be a wide packing; on a six-inch stem, decidedly a narrow one. Coming from the same spool, the reaction due to pressure is governed by the radius of curvature.

Another method of retarding the flow of oil and of the impregnation is the refinement of the packing pores and making the density as nearly uniform as possible.

Still another method of resisting the pressure is by means of moulded rings in which the action of seepage is controlled by mixtures injected into or forming the structure during the process of manufacture. Many of the disadvantages due to curvature are thus eliminated by a process, or at least compensated for. This type of packing is made with and without liquid impregnation, reaction to pressure by the non-liquid types being secured by walls extending from the stem to the stuffing-box wall.

Up to this point it has been taken for granted that in most packings a liquid is necessary to cause any kind of fibrous packing to react under pressure against the rod and the stuffing-box wall. In such packings when the liquid is forced out the packing becomes "dry" and leakage cannot be stopped, the great number of broken glands in the gas fields being an indication of the futility of trying. And a "dry" packing causes high friction, which is injurious to the stem, occasionally "freezing" to the stem after periods of idleness, and in general bringing other troubles, such as twisted stems and scoring.

How a fluid is to be maintained in a fibrous packing is of little moment; condensation of steam, water under pressure, oils from inside and from outside of the packing, and the like, are favorable conditions which prolong the reaction of a fluid tension type to pressure. But a packing exposed to a dry gas or a heated vapor is without the advantages of a continual supply of liquid, and this at once indicates a special and difficult case to hold for any length of time. If the packing was impregnated when installed, the first leakage may be stopped by compressing the rings and closing up the pores so that the remaining liquid will fill them. But when the adjustment is up, the oil forced out, there is nothing to do but repack, or let the set leak. Apparently a fluid tension packing is under a handicap when resisting a dry gas.

Natural gas is but one kind of a dry gas. It has peculiarities. Being explosive when mixed with the correct proportion of air, it is advisable to keep it confined. It also has a definite value, and leakage is an irreplaceable loss.

The foregoing relations—curvature, the width of the ring, the density of the packing structure, the viscosity of the impregnation—are questions of design and pertain to the

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packing while it is fresh, or when first installed. The three general forms of fibrous packing used on stems resisting natural gas—braided, amorphous and moulded—are affected in varying degrees by these inherent characteristics, and the total reaction to pressure by these three types is nearly alike while fresh or new. A choice based on technical advantages would be difficult to make. What happens after the packing goes into service is quite another matter. Investigation shows that the characteristics vary widely due to elapsed time, service and foreign matters.

The theory which justifies the construction of a packing for valve stem application, after being weighed according to what is certain to happen while exposed to natural gas in pipe line work, is still to be tested by certain compensations and destructive hazards of operation and application to valves. The two operating conditions are: Constant pressure on line work, intermittent service at stations. The items of valve construction are: The clearance between the stem and its housing, the thrust washer action, and the friction of a valve disc under pressure.

Nearly all valve stems are subject to movement off center, as they are not rigidly guided; the packing on both rotary and rising stems is the only bearing (there are some exceptions on those rotary stems having conical thrust washers). After a gate valve has been standing closed for some time, sand, rust and scale accumulate around the disc fit and it takes a heavy pull to move the stem. As this is usually done with a long bar, the stem is moved sideways and against the packing. The same sidewise movement occurs with flat thrust washers which are galded. During sidewise movement of a stem the packing must move with it or receive a heavy bearing load in addition to the thrust from pressure. As the gas is dry, the packing very likely so, the stem will be cut if the packing cannot accommodate itself to the change of position.

Valves at compressor stations are opened and closed many times in a day. It is essential that they remain tight and also operate freely. The number of times a valve stem is moved has most to do with the tightness of the packing. How much the stem is moved, and in what manner, is still another factor. Station stems which remain tight while the disc is open and under pressure, will often leak badly when closed and the pressure is reduced to a few pounds; such packings have enough elasticity to react against the stem while under pressure, but after the pressure is reduced and the stem moved, they are pulled away from the rod. Such a packing is invariably tightened, the matter forgotten when pressure is again returned by the opened gate. This additional stress on the packing shortens its life more than continual use.

If a stem under constant pressure is not disturbed for a long time, even after the usual impregnation is driven out, the fine particles of foreign matter will be driven into the pores and form a mat which will prevent leakage—pressure reaction is not necessary. But after a few movements of the stem the sharp abrasive materials are forced out at a high velocity to cut and enlarge the pores. Finally the openings are enlarged to the point that they will not be filled up, reaction is impossible and leakage continues.

Much has been said about reaction due to pressure. And considering the theories of various packing types, the inevitable action of a dry gas on their structures, the actions of foreign matters, the hazards of operation and the way packing is applied, it should be seen that adjustment of the gland is not a substitute for the automatic reaction of the packing due to pressure. Even if every valve stem packing could be constantly attended by a competent operator, there are certain factors which exist and certain happenings which are beyond his understanding or ability to remedy.

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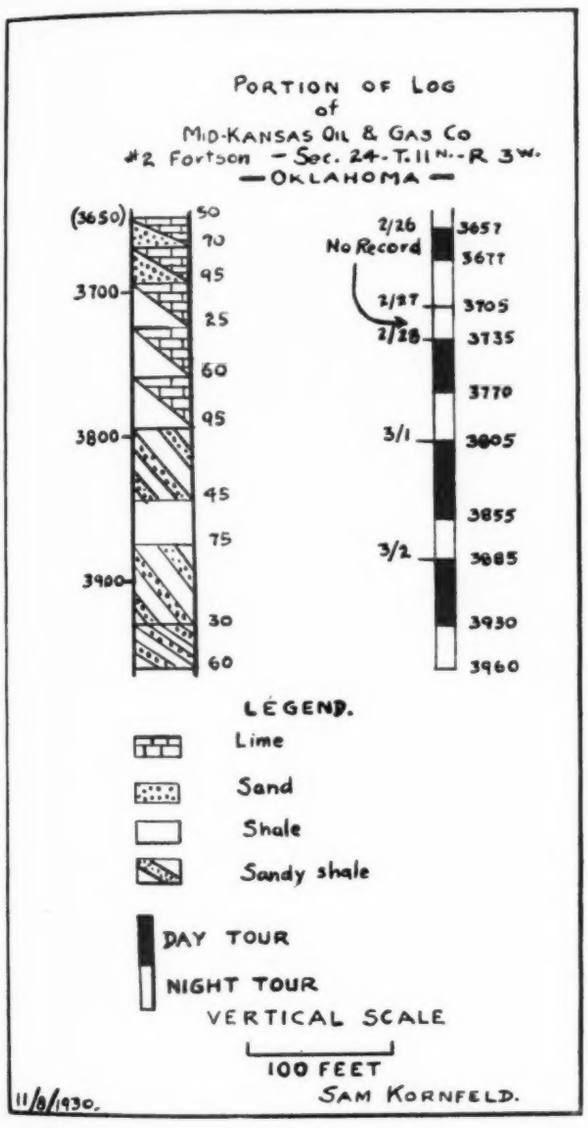
A New Graphic Log

By Sam Kornfeld

CHARTING a continuous record of drilling-footage-per-tour, along with a corresponding record of the formations drilled during the tour, offers many possibilities as an aid to the engineering and geological departments of oil companies. So far as is known, no concerted effort has been made to bring together these two types of data, although practically all operators keep such information in separate forms. One goes to the engineering department and the other to the geological department, while all of the data might be of benefit to both, if recorded in a condensed form which could be readily and conveniently interpreted.



The usual plotted log strip offers enough space for recording both types of information. For example, a portion of the formation log, together with the respective footage per tour, of a well in the Oklahoma City field is represented in the accompanying diagram. Date of drilling is shown at the top of each day's report. Explanatory details of drilling delays, such as shutdowns, fishing jobs, etc., can be noted where they occur. A two-color scheme, or a system of symbols, is feasible for designation of day and night tours.

The geologist will find in this an extra aid in geological correlation, especially in rotary drilling, where well samples

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From this one issue, regular departments such as Pictorial Petroleum, New Petroleum Equipment, Personals, etc., will be omitted to make room for the greatest possible amount of review material.

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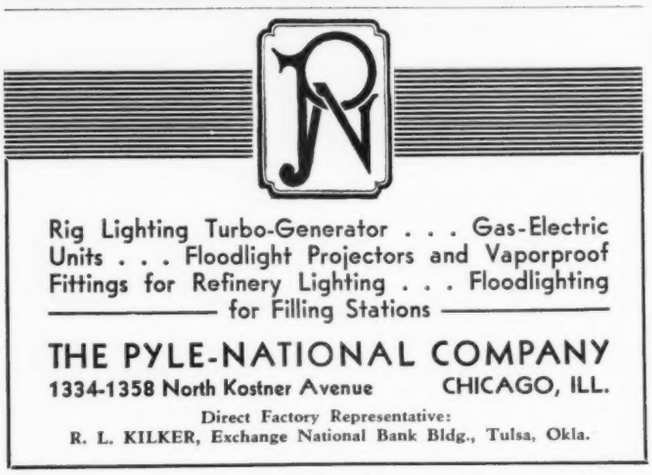
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are more or less unreliable. Variation in hardness of formation becomes apparent from quick inspection of the combination record, and, in the absence of well cuttings, transition from sedimentary to igneous, or sedimentary to metamorphic rocks, may be detected, thus assisting in correct logging of formation-contacts. The comparison of time-drilling logs in limestones, sandstones, shales, or metamorphis rocks may reveal sufficient differences to help materially in identification or correlation, where lithology is similar, or fossil evidence either meager or lacking.

For the petroleum engineer or the drilling contractor the following applications are logical:

(1) Time studies. Estimates of time necessary to drill a well can be made more feasible and accurate, and with less effort and trouble in looking up data.

(2) A convenient reference-guide in figuring drilling costs. Much information over a wide territory could be conveniently kept by compiling a type formation-log in conjunction with a footage-per-tour log for each locality.

Isolated wildcat wells, drilled at unusually great expense, lend themselves well to this type of investigation, as analysis of drilling performances in such cases may mean great economic savings in further operations in the same district.

A new type of graphical chart is thus suggested, together with possible benefits to various branches of oil and gas exploration. To be of maximum service, the systematic gathering, tabulating and filing of such foot-by-tour reports should be encouraged and effected for many fields, so that suitable studies can be made for different systems of drilling.

Jones Granted Dardelet License

DARDELET THREADLOCK CORPORATION has granted to the S. M. Jones Company of Toledo, Ohio, a license to manufacture and sell sucker rods with the Dardelet self-locking screw thread. With each shipment of Dardelet threaded rods, the S. M. Jones Company will deliver a certificate of insurance guaranteeing the payment of $30 for each joint broken while in service. This sum represents the cost of the broken rods and the average expense of recovering the broken string from the oil well.

Lucey Handles New Line

LUCEY PRODUCTS CORPORATION has been appointed distributor in the petroleum industry for Jenkins Valves, Scotch Gauge Glasses, and other control equipment manufactured by Jenkins Brothers of 80 White St., New York City. A complete stock of this equipment is now carried in the various Lucey stores throughout the Mid-Continent fields.

Welding Engineering Awarded New Contracts

THE Welding Engineering Company of Bartlesville, Oklahoma, has been awarded contracts for electric welding 100 miles of 18-inch and 20-inch pipe for the Columbia Gas Construction Company in Indiana; and for 190 miles of 20-inch and 22-inch for the Missouri-Kansas Pipe Line Company in Illinois, the general contractors on this line being Williams Bros., Inc., of Tulsa, Oklahoma. They have also completed the electric welding of approximately 600 miles of 24-inch pipe for the Continental Construction Corporation.

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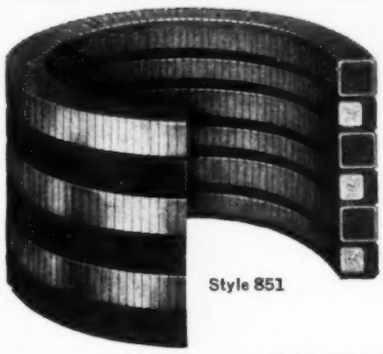

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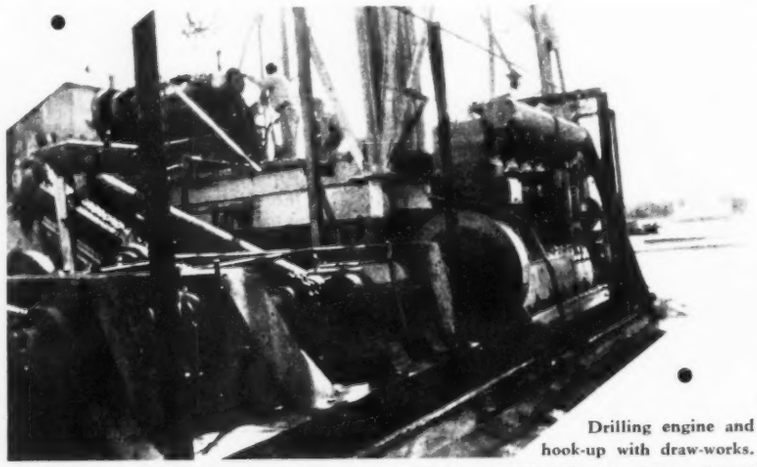
Drilling—Pumping—Refining

New Hook-Up Used on

AN entirely new type of rotary drilling mechanical hook-up has proven very successful in drilling a rank wildcat test 19 miles south of Reynosa, Mexico, a short distance across the Rio Grande River from McAllen, Texas. The test is Bravo No. 1, of the Cia de Petroleo Mercedes, and is the first well to depend upon this type of drilling hook-up. The success of the design is shown by the fact that not one minute's shutdown time has occurred to date on any of the equipment.

The test is unusual for several reasons in addition to its mechanical hook-up and equipment. While it is only 3,300 feet deep at this time, it is believed to have ample power for digging a 10,000-foot hole, and unless production is found in an upper horizon it may be carried to that depth, which would be the deepest oil test in the world. The only showing encountered has been gas found at about 2,000 feet. Salt water is being used for drilling purposes, as no available fresh water supply has been located in sufficient quantity and at close enough distance for use. The salt water supply comes from water holes.



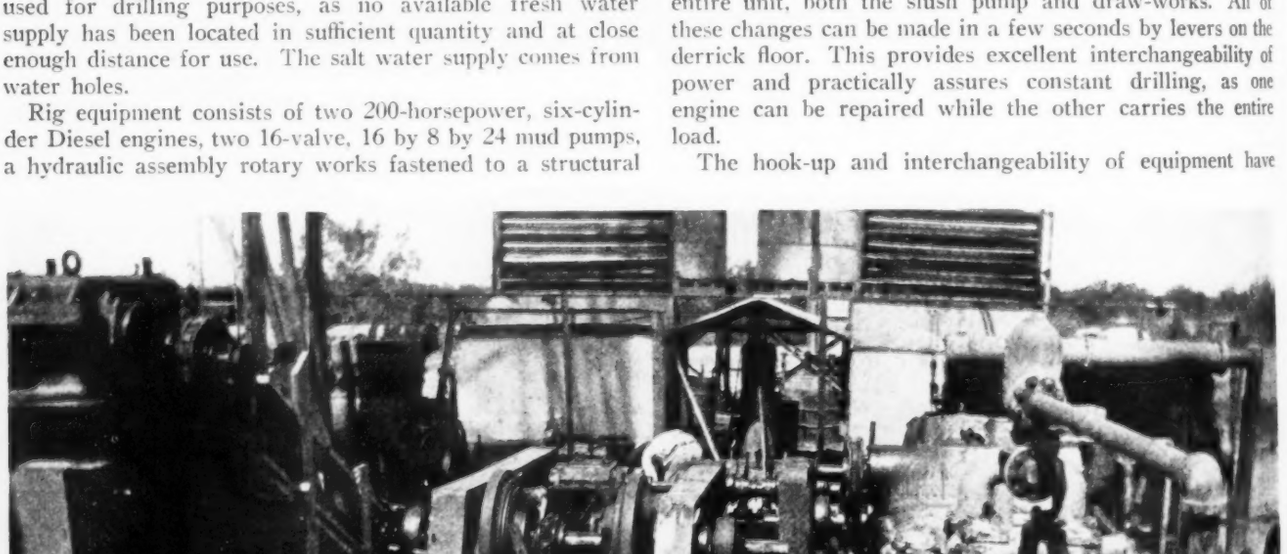
Drilling engine and hook-up with draw-works.

Rig equipment consists of two 200-horsepower, six-cylinder Diesel engines, two 16-valve, 16 by 8 by 24 mud pumps, a hydraulic assembly rotary works fastened to a structural steel base on which is mounted the six-speed draw-works, and a 136-foot steel derrick.

One of the Diesel engines is used for drilling. It is located just off the derrick floor and operates the draw-works through a clutch and chain drive to the transmission. The engine running the slush pump is set at one end of the drilling engine, with its driving end facing that of the drilling engine. Set in this manner, the two rotate in opposite directions and are so hooked-up through a gear box and series of clutches and shafts that either can take up, at once, the duties of the other engine.

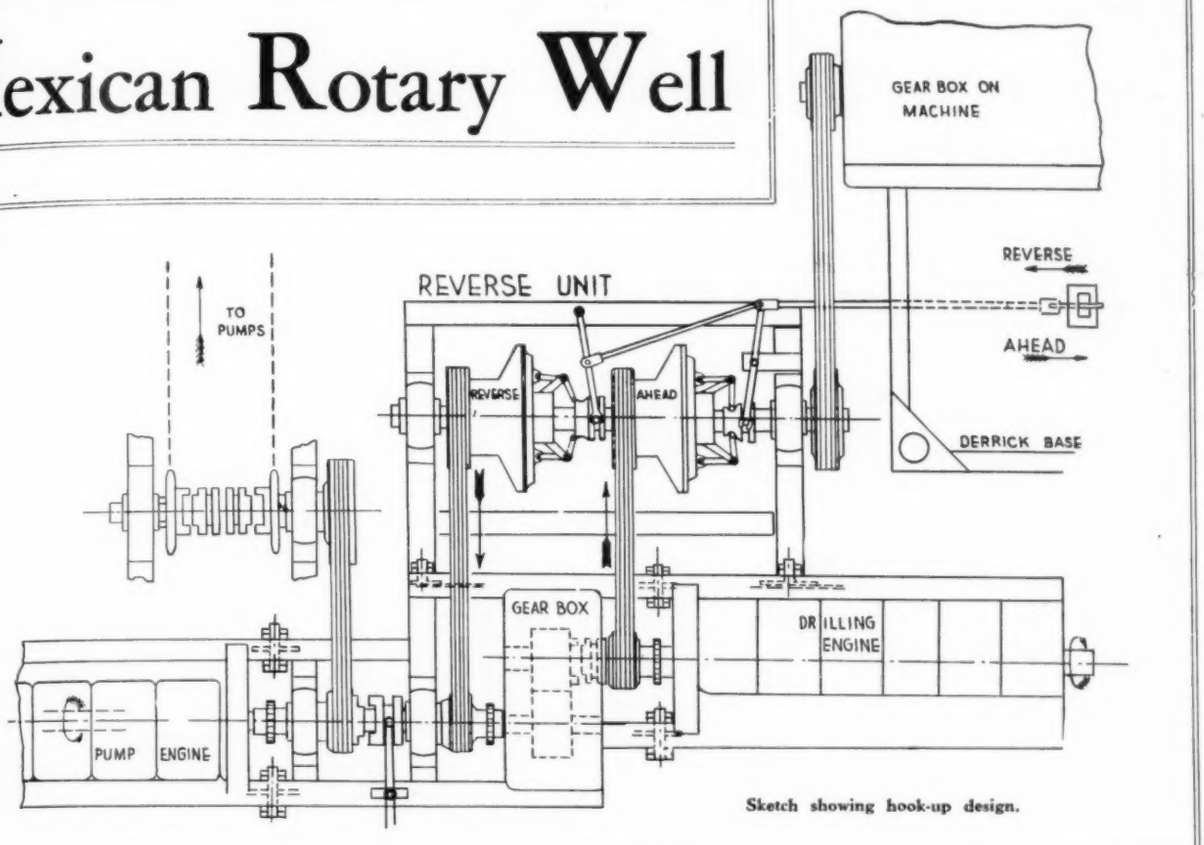
If it is desired to have the drilling engine operate the slush pump it is only necessary to throw in a clutch from the derrick floor and cut the other motor off in the same manner. The condition can be reversed and the slush pump will operate the draw-works. One engine can at the same time operate the entire unit, both the slush pump and draw-works. All of these changes can be made in a few seconds by levers on the derrick floor. This provides excellent interchangeability of power and practically assures constant drilling, as one engine can be repaired while the other carries the entire load.

The hook-up and interchangeability of equipment have



Clutch and gear arrangement.

Mexican Rotary Well



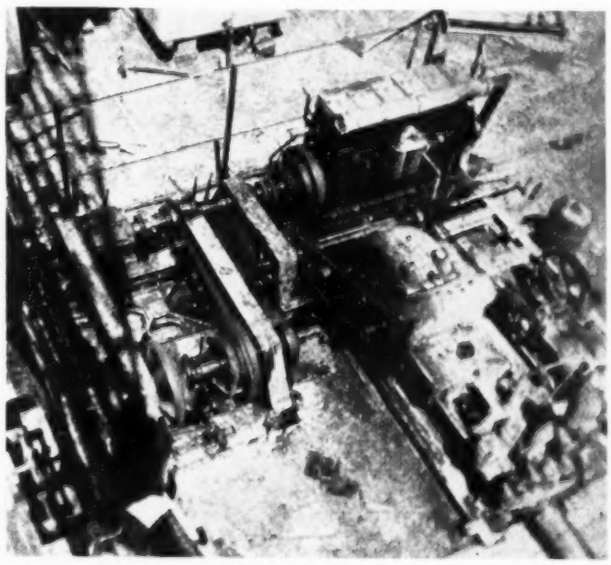
Sketch showing hook-up design.

attracted much attention, several prominent oil men having made trips to the well's location for a personal inspection of the unit.

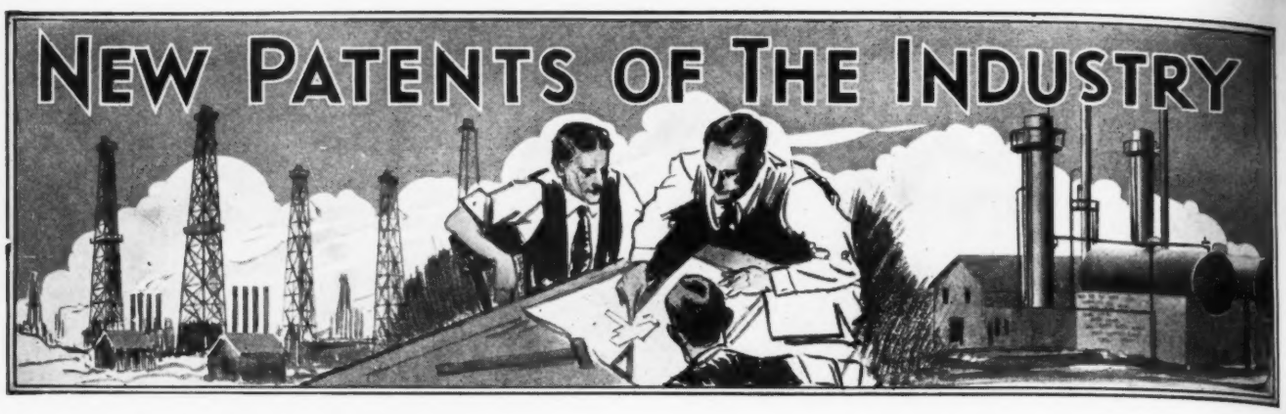
The draw-works in high gear has hoisted 3,300 feet of six-inch 30-pound drill stem, using only one engine, and never has the engine lost any of its full speed. This has been done although the draw-works is equipped with five other speeds. When bringing the pipe out of the hole it is pulled with four joints to the stand, the 136-foot derrick permitting the stacking of the extra joint in the rig. The only casing set in the hole has been the 13⅝-inch string set at 1,600 feet. Crude oil from the Mirando, Texas, field is being used as fuel in the two engines. The consumption has amounted to three barrels of oil per 24 hours for both engines. Fresh water for the engines is hauled three miles to the site of the well. Cooling towers are used to expose the water to the atmosphere. About 80 barrels of cooling water are used every day, of which it is figured that evaporation and wind loss account for one barrel every 24 hours.

Every precaution has been taken to make the rig as fire-proof an installation as possible. The exhausts from the engine have been run away from the location and exhaust gases are quite cool by the time they reach the end of the pipe and escape into the atmosphere.

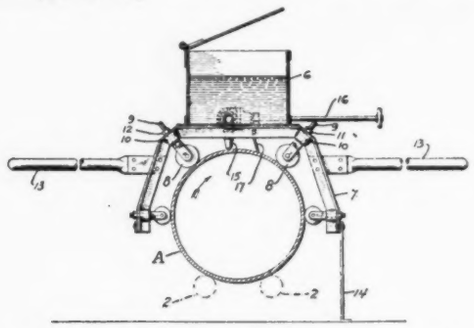
While this drilling unit has attracted much attention already, it is likely to create more interest as it reaches greater depths, especially should it be carried to depths now planned.



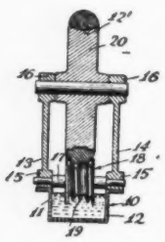
Looking down on a portion of the installation.



1,796,691. PIPE-COATING MACHINE. EMILE JANSEN, San Francisco, Calif., assignor to General Paint Corporation, San Francisco, Calif., a Corporation of Nevada. Filed May 28, 1930. Serial No. 456,780. 5 Claims. (Cl. 91—30.)



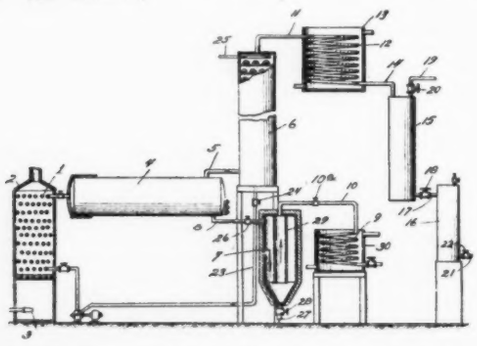
1. In a pipe coating machine, the combination with suitable means for revolving a pipe, of a coating device movably mounted thereon, said coating device having a container for the coating material and with a discharge outlet, a squeegee engaging the pipe and constituting a spreader to spread the material discharged as the coating device is moved longitudinally of the pipe.



1,794,725. LUBRICATING DEVICE. BURT S. MINOR, San Pedro, Calif. Filed Mar. 9, 1927. Serial No. 173,936. 2 Claims. (Cl. 184—17.)

1. A device for lubricating cable lines during their operation comprising a lubricant reservoir, a feeding wheel having concaved threaded periphery, a distributing wheel having a convexed elastic periphery engaging the threaded surface of a feeding wheel, said distributing wheel adapted to engage the grooved periphery of the cable sheave over which the cable line passes.

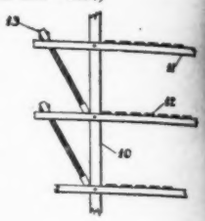
1,796,507. PROCESS AND APPARATUS FOR CONVERTING PETROLEUM OIL. ROY CROSS, Kansas City, Mo., assignor, by mesne assignments, to Gasoline Products Company, Inc., Wilmington, Del., a Corporation of Delaware. Filed July 9, 1924. Serial No. 724,995. 7 Claims. (Cl. 196—69.)

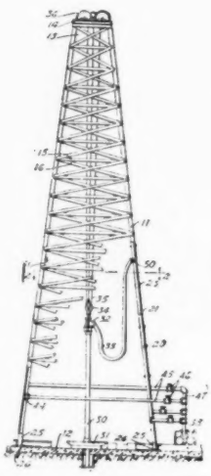


1. A process for converting petroleum oils, consisting in raising the oil to a cracking temperature without substantial conversion in a heating stage, collecting the oil in a substantial body and distilling off the lighter fractions in a vaporizing stage, refluxing and condensing the vaporized material, directing the unvaporized products to a stagnant pool adapted to be heated to facilitate settling of the free carbonaceous material, withdrawing separately the heavy settlings from the bottom of said pool and the liquid relatively carbon free oil from a vertical restricted column in said pool whereby turbulency in the oil body is prevented.

1,794,394. WATER-COOLING TOWER. CARL F. BRAUN, Pasadena, Calif., assignor to C. F. Braun & Co., Alhambra, Calif. Filed Sept. 14, 1928. Serial No. 306,063. 7 Claims. (Cl. 261—109.)

1. A water cooling tower of the atmospheric type in which a falling spray of finely divided water particles is maintained, said tower comprising a plurality of superposed perforate cooling decks, the perimeters of said decks being bounded by inclined perforated louvers whereby air may flow across the spray of water particles along paths through the louvers and between the louvers.





1,796,469. SPECIAL STANDPIPE REENFORCING FOR DERRICKS. JOHN B. MERRITT, Taft, Calif., assignor to Emsco Derrick & Equipment Company, Los Angeles, Calif., a Corporation of California. Filed Mar. 8, 1927, Serial No. 173,661. 8 Claims. (Cl. 255—24.)

1. In combination: A derrick having primary and secondary legs, one of said legs providing a chamber; a pump; means for connecting said pump to said chamber; a drill-pipe; and a flexible hose connected to said drill-pipe and said chamber.

1,794,427. APPARATUS FOR PUMPING WELLS. ARTHUR F. WHITE, Fullerton, Calif., assignor, by mesne assignments, to Jordan & Taylor, Inc., Los Angeles Calif. a Corporation of California. Filed Aug. 6, 1928. Serial No. 297,665. 3 Claims. (Cl. 103—234.)

1. In a displacement pump for pumping wells having a pump chamber formed therein, a compressed gas controlling valve comprising a valve body or head member including an intake passage communicating with a compressed gas supply, a valve chamber central with and communicating with said intake passage and communicating with the pumping chamber, a valve seat formed at the junction of said intake passage and said valve chamber; a gas inlet valve operatively mounted in said valve chamber and including a stem arranged to form a piston in said intake passage, a notch extending for a portion of the length of said stem, said notch arranged to permit the flow of compressed gas past said valve when said valve has moved a predetermined distance, and a valve head having a valve seat arranged to contact said valve body inlet passage seat and having gas passages positioned upon its periphery, a plunger slidably mounted in said valve chamber and having gas passages positioned upon its periphery, an inlet valve spring positioned between said gas inlet valve and said plunger, a plurality of vent passages communicating between said pumping chamber and the exterior of said displacement pump, and having valve seats; a plurality of vent passage valves, a valve member carrying said vent passage valves and engageable with said plunger, means pivotally mounting said valve member on said valve body for movement by displacement of said plunger to close said vent passages and a second spring means normally biasing said valve member to open said vent passages until the compressed gas pressure exceeds a predetermined value and displaces said inlet valve and said plunger.